A RAY TRACING DIGITAL COMPUTER PROGRAM FOR THE STUDY OF MAGNETOSPHERIC DUCT PROPAGATION

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FOREWORD

This NASA Special Publication is a documentation and discussion of a digital computer program used to conduct ray-tracing of electromagnetic waves in the magnetosphere. The publication consists of three sections. Section I contains a general description of the program and its capabilities. Section II assumes that the reader is aware of the scope of the program and provides all the information necessary for a non-programmer to run the program. Section III is a programming manual containing extensive information on the program structure. The program is designed to operate in the IBM 7094 IBSYS environment. It is written in Fortran IV but utilizes a MAP assembler subroutine to integrate the differential equations.

Ray-Tracing techniques are used extensively in the study and understanding of propagation of electromagnetic waves in any media (neutral, magneto-ionic, etc.). Combined with experimental data, the ray-tracing technique has served as a powerful tool in communications research. Data from NASA satellites (ISIS, Explorer, RAE, and the like) are better evaluated with the help of digital ray-tracing techniques. The present documented program has been used by the authors in studying the data from the ISIS topside sounder experiments. However, the program is applicable to any medium with suitable choice of models.

Jayaram Ramasastry

Edward J. Walsh

April 1969

TABLE OF CONTENTS

INTRODUCTION

This report consists of three sections. Each section is intended to be an independent treatment of a specified aspect of reader interest.

Section I contains a general description of the program so that the reader can gain a general idea of the program's capability.

Section II assumes that the reader is aware of the scope of the program and that he intends to use this program in ray tracing analyses. Section II contains all the detailed information necessary for a non-programmer to run the program.

Section III is a programming manual containing detailed information on the program structure.

This program is designed to operate in the IBM 7094 IBSYS environment. The basic program is written in FORTRAN IV but utilizes a MAP assembler subroutine to integrate the differential equations.

The program can be considered to consist of five major parts:

(1) An executive routine which governs program flow

(2) An input section to assess the initial data necessary to operate the program.

(3) An output which prints a history of the path of the ray and under option governs the generation of a plotting tape

(4) Three mathematical models which characterize the electromagnetic properties of the magnetosphere

(5) An integration routine which evaluates the differential equations

The ray-tracing technique has been used by many people in ionospheric and magnetospheric propagation research. Actual ray-paths and signal characteristics (like attenuation, path-loss, doppler shift, and refraction) in model atmospheres and ionospheres are computed using the ray-tracing program. Because of the high accuracy obtainable, the use of a high-speed digital computer is preferred to an analog machine for the integration of the ray equations.

The ray-tracing program used in our study is based on the Hamilton system of equations as derived in spherical polar coordinates by Haselgrove and extended by Grossi and Langworthy for the investigation of HF and VHF ionospheric propagation. The particular problem concerning our study is the guided propagation of high frequency radiowaves along the magnetic field lines of the Earth. Some of the echo traces appearing at virtual ranges greater than those of the normal vertical incidence echo traces on the topside-sounder ionograms have been explained in terms of guided propagation of radiowaves along the field-lines. The guided propagation along the field-line is made possible by field-aligned ionization irregularities (e.g., ducts and shells) of suitable scale sizes and enhancements or depletions. The irregularities are assumed to have thickness greater than the radio wavelength and hence act as waveguides or "ducts" to trap HF energy and produce the long-range echo traces. The guiding of rays along field-lines requires irregularities with a certain minimum transverse ionization gradient. Propagation between magnetic conjugate points or "conjugate ducting" occurs when the transverse ionization gradient exceeds the minimum required for guidance at the apex of the magnetic line of force. Conjugate echoes are recorded by the topside sounder receivers when the signal traverses to and from the conjugate reflection points along the magnetic field-line passing through the satellite. Knowing the satellite orbital parameters and the transmitted signal parameters, one could conduct ray-tracing utilizing realistic models for the magnetosphere. The ray-tracing program yields such useful information as the criteria for guidance, the group-delays of the trapped signals of various frequencies, and total path length traversed. Ray-tracing method is a powerful tool when used alongside experimental observations since it gives a better insight into the observed results.

I. GENERAL PROGRAM DESCRIPTION

Introduction

This section provides a general description of the capabilities of the program. Major emphasis is placed on the program input and output and the basic formulation of the differential equations.

The integration technique is discussed only briefly but reference is made to Appendix A where the integration package is described in detail.

The three models characterizing the electromagnetic properties of the magnetosphere (electron density, collision frequency and magnetic field) are discussed briefly in this section and their detailed descriptions are presented in Section III.

Main Program

The following equations form the basis of the ray tracing program. The first six equations are the Hamilton electromagnetic wave equations in spherical coordinates. The remaining five equations are additional functions of phase path length. All derivatives indicated with a dot are with respect to phase path length in km.

The ray is described in terms of position in spherical polar coordinates with origin at the center of the Earth and in terms of the components of the wave normal y_1, y_2, y_3 in the r, θ, ϕ directions, respectively. Figure 1 describes the ray position geometry in spherical coordinates.

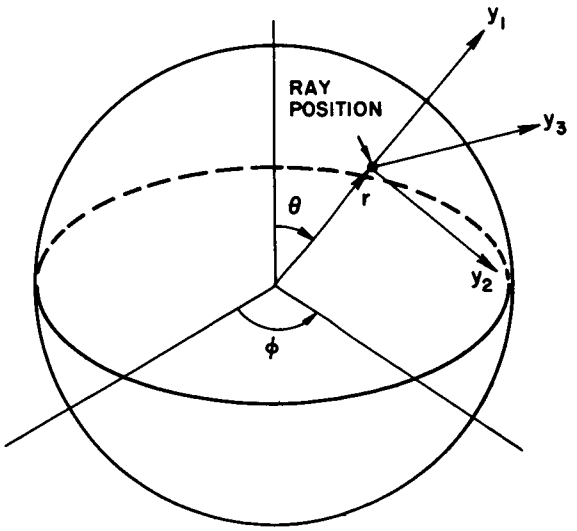


Figure 1. Ray Position in Spherical Coordinates.

Equation #		Initial Condition
1	$\dot{r} = \frac{1}{\mu^2}\left(y_1 - \mu\frac{\partial\mu}{\partial y_1}\right)$	$r(o) = r_o$
2	$\dot{\theta} = \frac{1}{\mu^2 r}\left(y_2 - \mu\frac{\partial\mu}{\partial y_2}\right)$	$\theta(o) = \theta_o$
3	$\dot{\phi} = \frac{1}{\mu^2 r\sin\theta}\left(y_3 - \mu\frac{\partial\mu}{\partial y_3}\right)$	$\phi(o) = \phi_o$
4	$\dot{y}_1 = \frac{1}{\mu}\frac{\partial\mu}{\partial r} + \dot{\theta}y_2 + \dot{\phi}y_3\sin\theta$	$y_1(o) = y_1$
5	$\dot{y}_2 = \frac{1}{r}\left(\frac{1}{\mu}\frac{\partial\mu}{\partial\theta} - \dot{r}y_2 + \phi y_3 r\cos\theta\right)$	$y_2(o) = y_2$
6	$\dot{y}_3 = \frac{1}{r\sin\theta}\left(\frac{1}{\mu}\frac{\partial\mu}{\partial\phi} - \dot{r}y_3\sin\theta - \dot{\phi}y_3 r\cos\theta\right)$	$y_3(o) = y_3$
7	$\dot{G} = 1 + \frac{f}{\mu}\frac{\partial\mu}{\partial f}$	$G(o) = 0.0$
8	$\dot{S} = \frac{1}{\mu c\phi s\alpha}$	$S(o) = 0.0$
9	$\dot{D} = -\frac{2K}{\mu}D$	$D(o) = 1.0$
10	$\dot{E} = \frac{1}{\mu}\frac{\partial\mu}{\partial\phi}$ and $\dot{\Delta}f = -\frac{f}{c}\dot{E}$	$E(o) = 0.0$ $\Delta f(o) = 0.0$
11	$\dot{P}_F = \frac{\nabla^2\tau}{\mu^2 c\phi s\alpha}$	$P_F(o) = 0.0$

where:

$\mu \equiv$ phase refractive index

$r \equiv$ geocentric radius of the wave front

$\theta \equiv$ colatitude of the wave front

$\phi \equiv$ longitude of the wave front

$(y_1, y_2, y_3) \equiv$ components of the wave normal in the θ, θ, and ϕ directions

$G \equiv$ group path length

$S \equiv$ ray path length

$D \equiv$ powerloss due to absorption

$E \equiv$ coefficient used to compute the doppler shift, see Section III

$P_F \equiv$ coefficient used to compute the doppler shift, see Section III

$\tau \equiv$ eikonal function that has the property that the surface τ = constant, is the geometrical wave front

$\alpha \equiv$ angle between the wave normal and the wave front

The powerloss calculation, Eq. (11), is optional and may be suppressed if this data is of no interest to the user.

A complete description of all calculations can be found in section III.

Input Section

The input routine is written with the aim of providing maximum control over the operation of the program and at the same time minimize the size of the input deck. The NAMELIST feature of FORTRAN IV is used because it gives the user maximum flexibility and also tends to minimize the careless errors usually associated with fixed format input statements.

The input data is divided into three major parts:

(1) The data required to describe the initial position, direction and characteristics of the ray

(2) Optional integration parameters

(3) Optional limits for the axes of the calcomp plots

The required program inputs are:

(1) Starting position and direction of the electromagnetic wave, which is referred to as a "ray"

(2) Integration stops or triggers which either temporarily or permanently halt the integration procedure

(3) Propagation frequency, and ray mode (ordinary or extraordinary)

(4) Output controls, print and plotting intervals

(5) Option indicators

(6) Optional input indicators

All optional parameters are preset in the program. If, however, any or all of these parameters must be changed, the program allows for easy modification of these nominal values.

For a complete description of all required and optional inputs, see section II.

Output Section

All output, with the exception of a list of the case inputs, is performed by subroutine OUTPUT. This subroutine not only prints a history of the path of the ray, but under option control governs the plotting of the data.

Printed output.- Results are printed whenever one of the following situations occur:

(1) A print time is reached. Print time is a function of phase path length. A print time occurs at $n \cdot \Delta hp$ where $n = 0,1,2,3...$ and Δhp is some increment in phase path length, measured in kilometers.

(2) The rate of change of the geocentric radius, r, is approximately equal to zero.

(3) A stopping condition has been reached.

(4) A reflection has occurred.

The printed output consists of a sequence of 3 x 7 matrices grouped thirteen per page. The first matrix in the sequence, printed at the top of the page, is a heading matrix which identifies each data element of the data arrays. The heading definitions are listed below according to row and column.

Row	Column	Title	Description
1	1	PHASE PATH	Phase path length, hp, from (r_o, θ_o, ϕ_o) in kilometers.
1	2	RADIUS	Geocentric radius, r, of the ray position in kilometers.
1	3	COLATITUDE	Colatitude, θ, of the ray position, in degrees.
1	4	LONGITUDE	Longitude, ϕ, of the ray position, in degrees.
1	5	ABSORPTION	Absorption loss, D.
1	6	DOPPLER, SP	Doppler shift
1	7	POWER LOSS	Power loss, $\frac{P_{RO}}{P_T}$, exclusive of absorption
2	1	GROUP PATH	Group path length, G, in kilometers
2	2	Y_1	Vertical component, Y_1, of the wave normal
2	3	Y_2	Southerly component, Y_2, of the wave normal
2	4	Y_3	Easterly component, Y_3, of the wave normal
2	5	MU**2	Square of the Index of refraction (μ^2)
2	6	Y**2	$Y_1^2 + Y_2^2 + Y_3^2$
2	7	EPSTEIN CD	Epstein condition

Row	Column	Title	Description
3	1	RAY PATH	Ray path length, s, in kilometers
3	2	POLARIZATION -MOD AND ARG	Modulus and argument of the wave polarization term, R.
3	4	DEL MU	Validity criterion
3	5	N	Electron density, N, in electrons/cc
3	6	NU	Collision frequency, ν, in collisions/sec.
3	7	GROUP DELAY (Gd)	Group delay in milliseconds. (Group path length divided by the velocity of light in free space.)

An example of the printed output can be found in Table I. Whenever results are printed because of any one of the stopping conditions, an appropriate message is printed below the data to which the message refers.

Plotted output.- Each output plot consists of two plots. The rectangular plot shows the distance of the ray normal to the field line from the near end. The polar plot shows the actual ray path with reference to the surface of the Earth. The polar plot gives a clear indication of the positions of the conjugate reflection points as well as the L value of the field line guiding the rays. A complete description of the plotting routine can be found in section III.

Some examples of the plotted output are described in the following paragraphs.

Examples

Figures 2 through 4 show a few results of the ray tracing. They are chosen so as to demonstrate the capabilities of the program. Figure 2 is a single plot which simulates a conjugate echo path observed in an Alouette 2 ionogram. Figure 3 is an overlayed plot of two rays launched from the same point but with different launch angles, DELAO. Figure 4 is an overlayed plot of four rays launched from the same point with identical launch angles but at different frequencies.

Parameters shown in the figures are defined as follows:

RO = the geocentric radius in km of the initial signal position

TABLE I

EXAMPLE OF PRINTED OUTPUT

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION - MOD AND ARG	COLATITUDE Y2	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CO GROUP DELAY
2.0000000E 01	9.3041084E 03	7.7566658E 01	8.9999987E 01	9.9999999E-01	0.0000000E-39	0.0000000E-39
2.4031575E 01	3.7083140E-01	8.4940216E-01	-0.0000000E-39	8.5899997E-01	8.5899995E-01	3.2884926E-13
2.1583306E 01	1.0000023E 00	-9.0000000E 01	2.1791243E-05	1.2074153E 03	8.6929314E-06	8.0105249E-02
2.0000000E 02	9.3790591E 03	7.8663387E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3919784E 02	3.5227335E-01	8.6049035E-01	0.0000000E-39	8.6454017E-01	8.6454015E-01	1.8393076E-13
2.1547645E 02	1.0000086E 00	-9.0000000E 01	1.2532970E-05	1.1775214E 03	5.1706413E-06	7.0732613E-01
4.0000000E 02	9.4549106E 03	7.9885571E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.7618443E 02	3.1247831E-01	8.7869874E-01	0.0000000E-39	8.6975418E-01	8.6975416E-01	1.0242290E-13
4.3024053E 02	1.0000091E 00	-9.0000000E 01	7.7818205E-06	1.1486853E 03	3.0565067E-06	1.5872814E 00
6.0000000E 02	9.5232201E 03	8.1110764E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
7.1136256E 02	2.7305632E-01	8.9420258E-01	0.0000000E-39	8.7415765E-01	8.7415764E-01	6.0527487E-14
6.4441360E 02	1.0000071E 00	-9.0000000E 01	1.6612134E-05	1.1237326E 03	1.9024320E-06	2.3712085E 00
8.0000000E 02	9.5831912E 03	8.2340916E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
9.4506111E 02	2.4719298E-01	9.0372165E-01	0.0000000E-39	8.7781720E-01	8.7781718E-01	3.8245256E-14
8.5809700E 02	1.0000027E 00	-9.0000000E 01	2.1914030E-05	1.1025245E 03	1.2563415E-06	3.1502037E 00
1.0000000E 03	9.6338651E 03	8.3576100E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.1775500E 03	2.1059714E-01	9.1457866E-01	0.0000000E-39	8.8080530E-01	8.8080528E-01	2.5948592E-14
1.0713754E 03	1.0000034E 00	-9.0000000E 01	9.8592200E-06	1.0848494E 03	8.8431544E-07	3.0251668E 00
1.2000000E 03	9.6763511E 03	8.4814052E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.4090642E 03	1.6285635E-01	9.2559346E-01	0.0000000E-39	8.8324545E-01	8.8324544E-01	1.8751383E-14
1.2843241E 03	1.0000041E 00	-9.0000000E 01	1.0791444E-05	1.0700884E 03	6.5878622E-07	4.6968806E 00
1.4000000E 03	9.7104039E 03	8.6054828E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.6398141E 03	1.2611563E-01	9.3235042E-01	0.0000000E-39	8.8518248E-01	8.8518245E-01	1.4453184E-14
1.4970117E 03	1.0000010E 00	-9.0000000E 01	2.3180092E-05	1.0580794E 03	5.2030317E-07	5.4660469E 00
1.6000000E 03	9.7546377E 03	8.7298759E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.8699834E 03	9.5122531E-02	9.3677850E-01	0.0000000E-39	8.8660226E-01	8.8660225E-01	1.2002435E-14
1.7094989E 03	1.0000070E 00	-9.0000000E 01	1.5447359E-05	1.0490262E 03	4.3987898E-07	6.2332779E 00
1.8000000E 03	9.7496772E 03	8.8544160E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.0997386E 03	4.7070662E-02	9.4092793E-01	0.0000000E-39	8.8756100E-01	8.8756102E-01	1.0686431E-14
1.9216413E 03	1.0000001E 00	-9.0000000E 01	9.0264119E-06	1.0426152E 03	3.9635041E-07	6.9991287E 00
2.0000000E 03	9.7962792E 03	8.9790206E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3292425E 03	5.3855051E-04	9.4239670E-01	0.0000000E-39	8.8811183E-01	8.8811182E-01	1.0141845E-14
2.1340939E 03	1.0000062E 00	-9.0000000E 01	1.7753554E-05	1.0385536E 03	3.7861936E-07	7.7641417E 00
2.0026441E 03	9.7562800E 03	8.9806684E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3322757E 03	-9.9151940E-05	9.4239864E-01	0.0000000E-39	8.8811521E-01	8.8811520E-01	1.0141433E-14
2.1368996E 03	1.0000064E 00	-9.0000000E 01	1.7272333E-05	1.0385236E 03	3.7861733E-07	7.7742522E 00

6 RUOI = -0.2560182E-10

PKFRAC = the peak fractional ionization enhancement

LAMBDA = the colatitude of the field line

AO = the initial angle the ray makes with the local vertical

BO = the initial angle the ray makes with the south vector

DELAO = the initial angle the ray makes with a line drawn parallel to the tangent of the field line at RO

PHI & THETA = the magnetic longitude and colatitude of the initial signal position

HO = the scale size of the duct at the base of the field line

FREQ = the frequency of the initial signal

The ray mode (ordinary or extraordinary) is also indicated.

Each figure consists of two plots. The rectangular plot shows the distance of the ray normal to the field line versus the distance along the field line from the near end. The polar plot shows the actual ray path with reference to the surface of the Earth. The polar plot gives a clear indication of the positions of the conjugate reflection points as well as the L value of the field line guiding the rays.

All cases are for the L = 1.53 field line using a peak electron density enhancement of 5.0 percent at the point the ray is launched. The rays are all of the extraordinary mode.

In Figure 2 the ray has an initial geocentric radius of 9295.40 km. This corresponds to a distance of about 2.75 km from the field line at a colatitude of 77.445 degrees. The ray starts at about 4,500 km along the field line from its base in the northern hemisphere. It passes from north to south and is reflected in the southern hemisphere. After reflection it travels back into the northern hemisphere where it is again reflected. The program was deliberately stopped after the second reflection.

The slight bowing observed in the path of the ray near the equator is caused by the larger scale size near the equator. The larger scale size causes the enhancement structure to be wider. Thus, the ray rides further out from the field line.

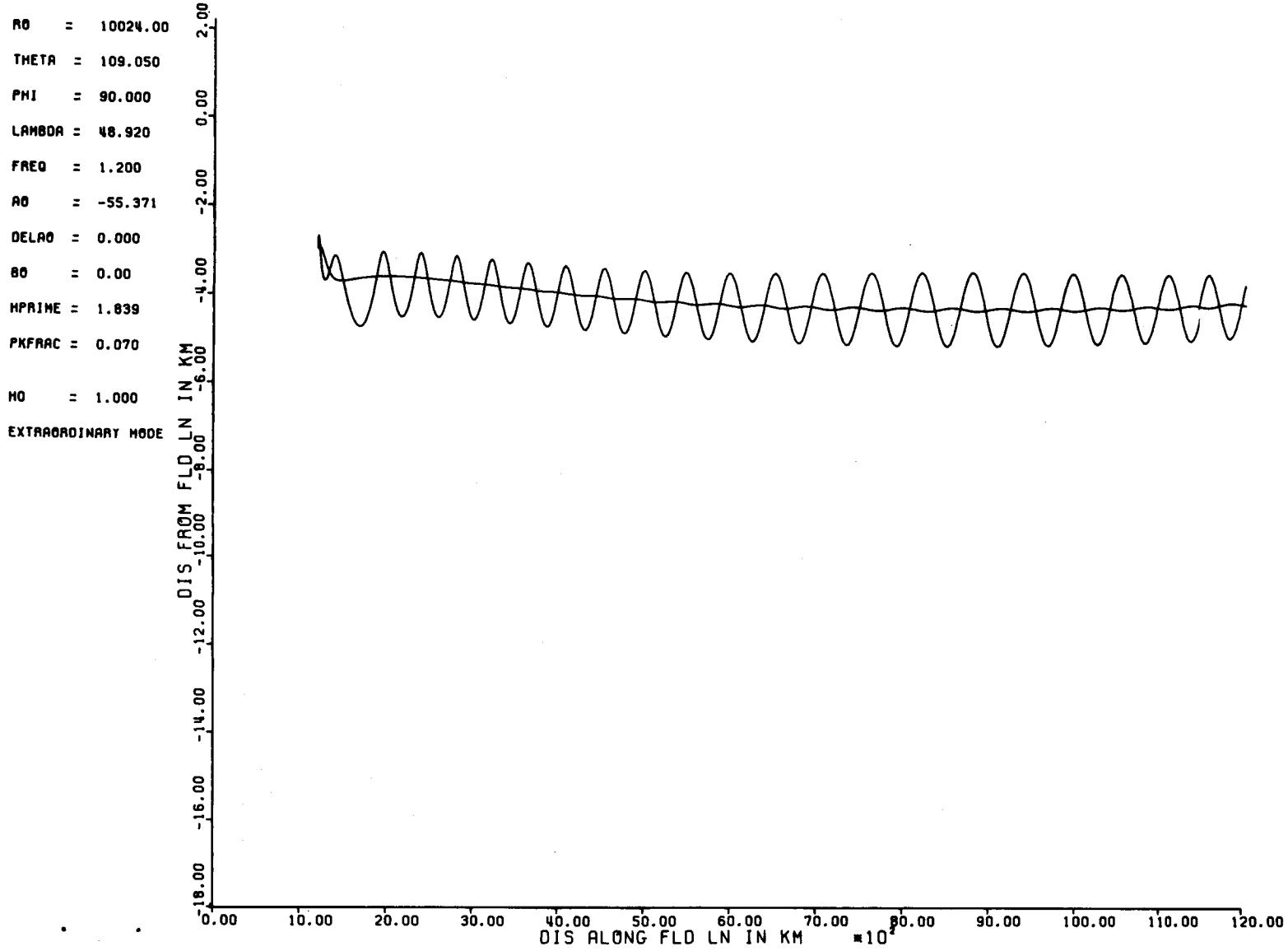


Figure 2A. - Single Plot Simulating a Conjugate Echo Path Observed in Alouette 2

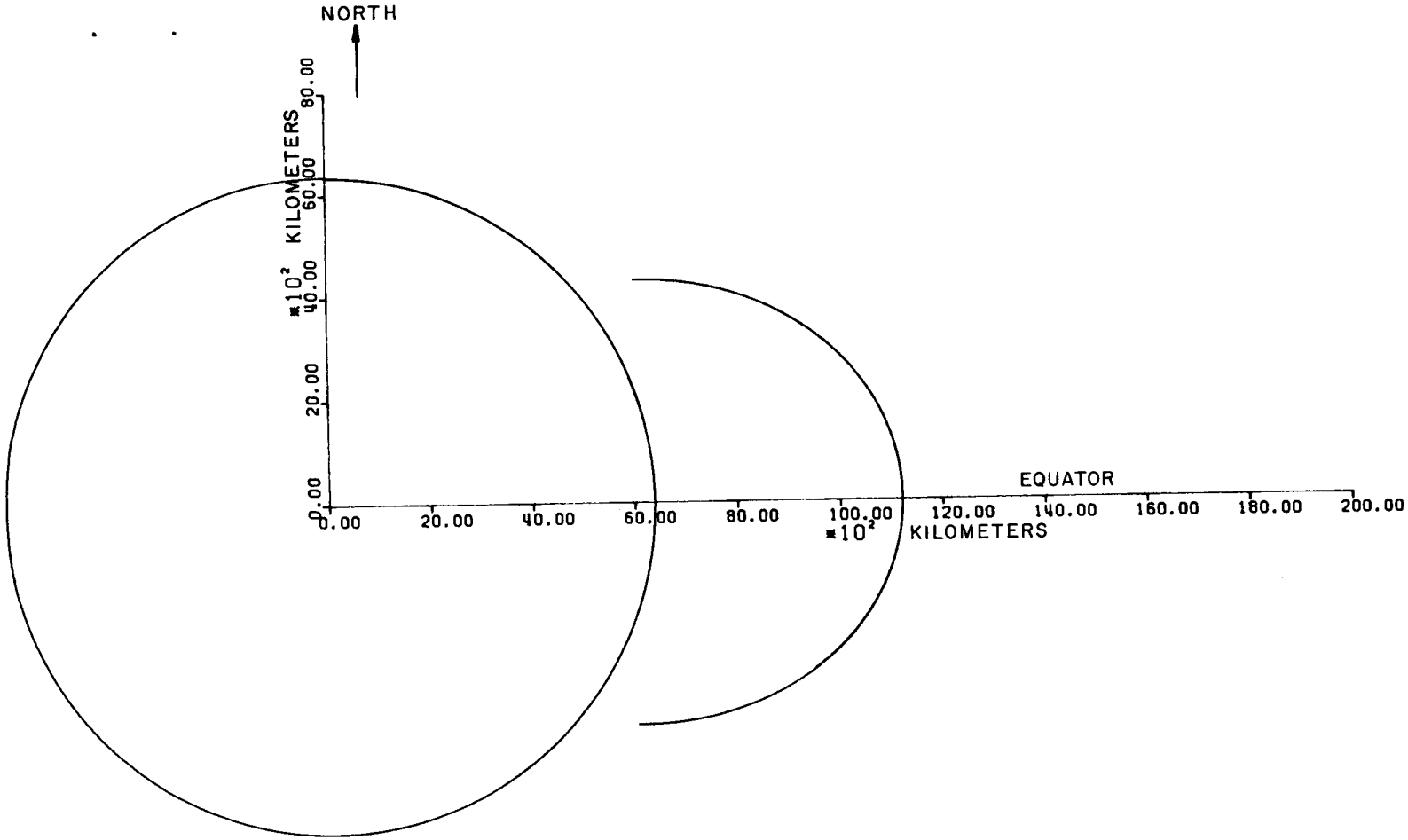


Figure 2B. - Single Plot Simulating a Conjugate Echo Path Observed in Alouette 2.

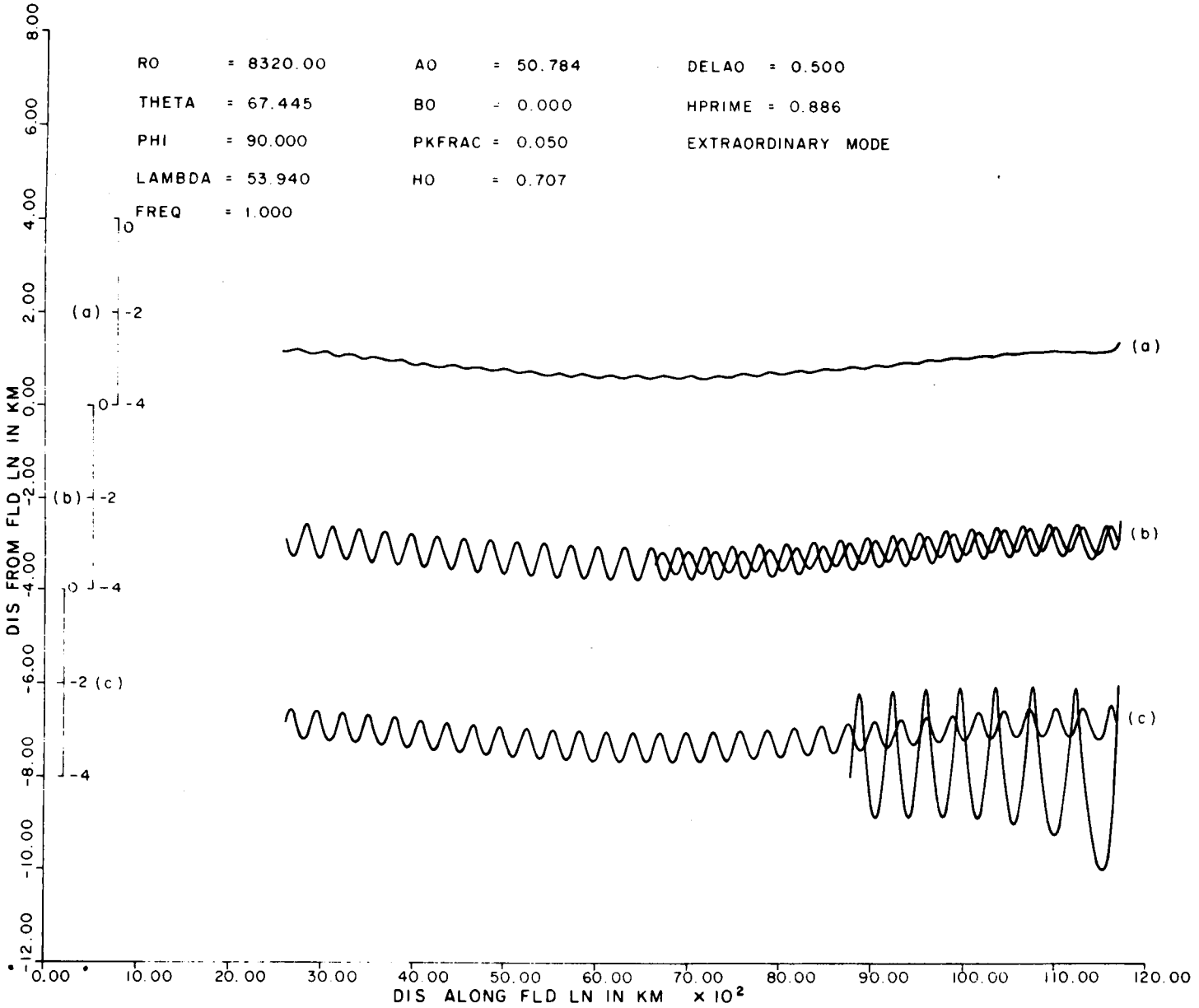


Figure 3. - Overlayed Plot of Two Rays Launched from the Same Point but with Different Launch Angles, DELAO

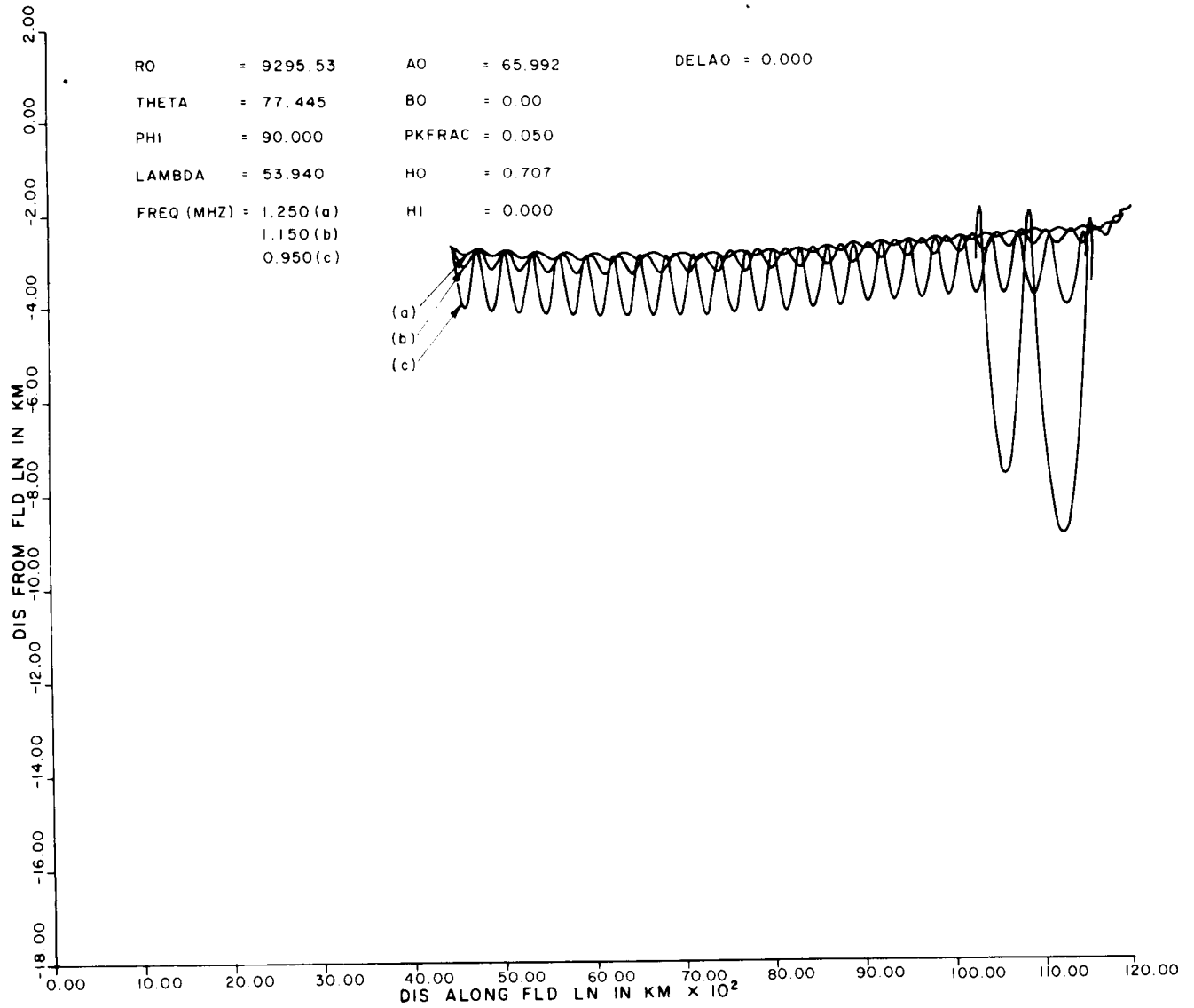


Figure 4A. - Overlayed Plot of Four Rays Launched

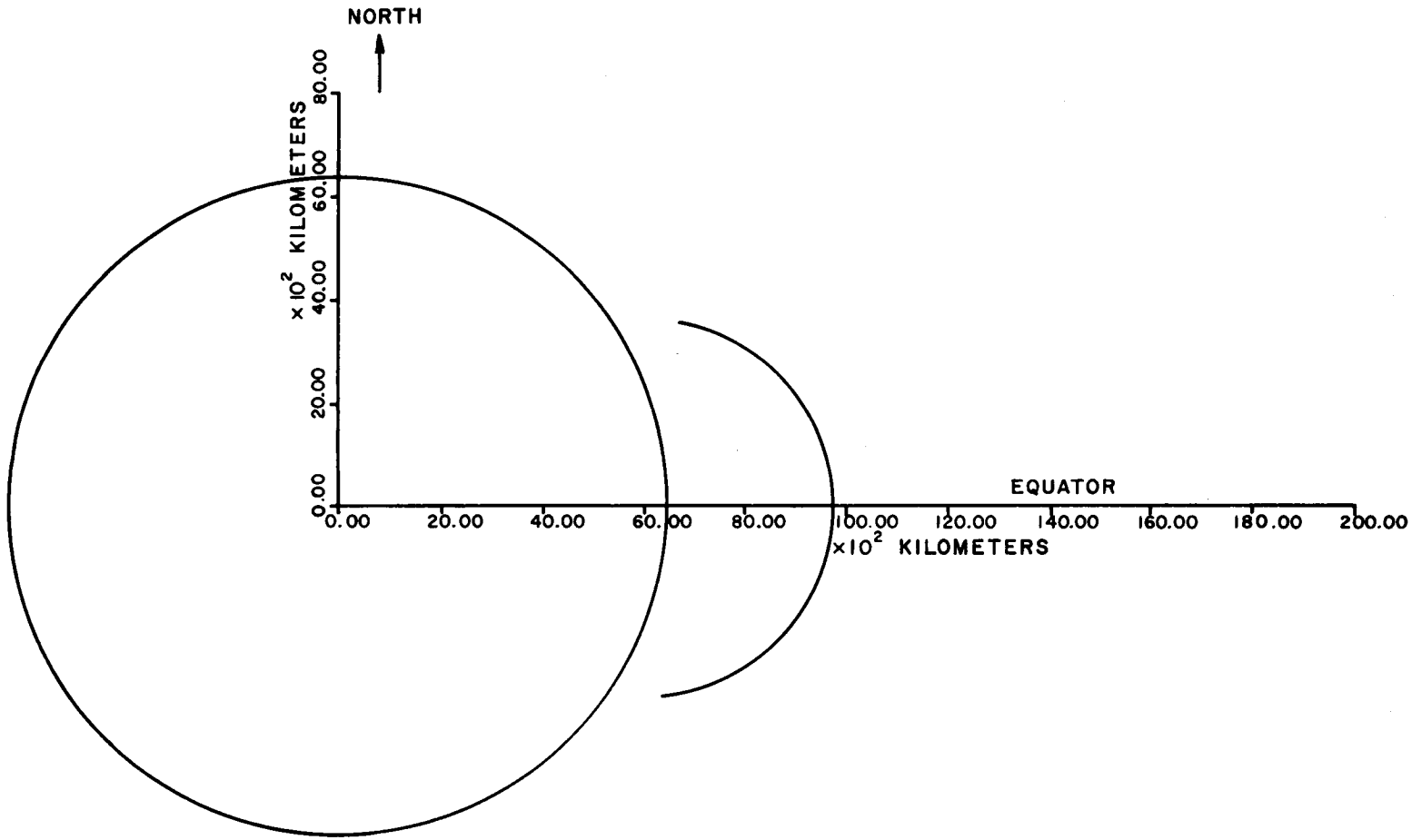


Figure 4B. - Overlayed Plot of Four Rays Launched

The oscillatory nature of the ray path seen in the rectangular plot is caused by the ray being launched at a point where the electron density gradient is greater than necessary for guidance. The ray tends to oscillate about a point where the electron density gradient is just sufficient to guide the ray parallel to the field line. A careful launching of the signal can minimize these initial oscillations. In this figure the oscillations were somewhat damped upon reflection. However, this is not always the case. For example, in Figure 4 the amplitude of the oscillations after reflection was actually increased.

Figure 3 shows three rays launched from the same point but with different launch angles, DELAO. The launch angles corresponding to plots (a), (b) and (c) are 0 degrees, - 0.5 degrees and + 0.5 degrees, respectively. The oscillatory nature of the ray paths in plots (b) and (c) once again demonstrates that the rays were launched off the equilibrium position. The rays started in the northern hemisphere about 2500 km along the field line and propagated along the field line to the southern hemisphere down to the reflection level. After reflection, they retraced their path and returned to the reflection level in the northern hemisphere and were again reflected. The program was stopped at this point because two reflections were counted.

In Figure 4, one can observe the behavior of waves at different frequencies. Three rays are launched from the same point with identical launch angles. The enhancement model is the same but the three rays differed in their frequencies. The three frequencies are 0.95, 1.15, and 1.25 MHz. The ray with a frequency of 0.95 MHz has the greatest amplitude of oscillation and the ray with the frequency of 1.25 MHz has the minimum initial oscillations. The rays were launched in the southern hemisphere at a colatitude of 77.445 degrees. The rays passed from south to north. Only one ray was reflected back into the duct at the conjugate reflection point. The other two escaped upon reflection. The inverse proportionality of the oscillation amplitude to frequency indicates that higher electron density gradients are required to guide the rays of higher frequencies.

Figures 5A, B; 5C, D, and 5E, F correspond to cases where a frequency of 1.2 MHz is trapped in enhancement ducts of different peak fractional enhancements. The ray launching position and the launch angle is the same for all the three cases. However, the peak fractional enhancements are 5, 6 and 7 percent for Figures 5A, 5C, and 5E, respectively. It may be noticed that in Figure 5A, the peak fractional enhancement of 5 percent is not sufficient to contain the ray on its way back from the reflection point in the northern hemisphere. Peak fractional enhancements of 6 and 7 percent as shown in Figures 5C and 5E seem sufficient to trap the rays and when the program was terminated after two reflections, the rays were still well trapped.

Magnetospheric Models

The following characterizes properties of the magnetosphere:

(1) The electron density distribution

(2) The magnetic field distribution

(3) The electron collision frequency distribution

The mathematical models for these quantities have been implemented in the form of subroutines and can be independently modified as necessary.

Magnetic field model.- A dipole model is used for the magnetic field of the Earth. The magnetic field equation which defines gyrofrequency, f_H, is given by:

$$f_H(r, \theta) = C_{11} \left(\frac{a}{r}\right)^3 \left[1 + 3\cos^2\theta\right]^{1/2}$$

where a = 6378.0, the radius of the earth in km, and r and θ are the geocentric distance and colatitude of any point on the field line.

$$C_{11} = \frac{e}{2\pi m} B_o * 1.0E\text{-}6 \doteq 0.9$$

where B_o is the magnetic field on the surface of the Earth at the equator, and e and m are the charge and mass of an electron. A value of 0.3142 Gauss is used for B_o.

The angle between the magnetic field direction and the wave normal is given by

$$\cos\psi = \frac{2Y_1\cos\theta + Y_2\sin\theta}{\left[\left(\sum_{i=1}^{3} Y_i^2\right)\left(1 + 3\cos^2\theta\right)\right]^{1/2}}$$

$$\sin\psi = \frac{2Y_2\cos\theta - Y_1\sin\theta}{|2Y_2\cos\theta - Y_1\sin\theta|}\left(1-\cos^2\psi\right)^{\frac{1}{2}}$$

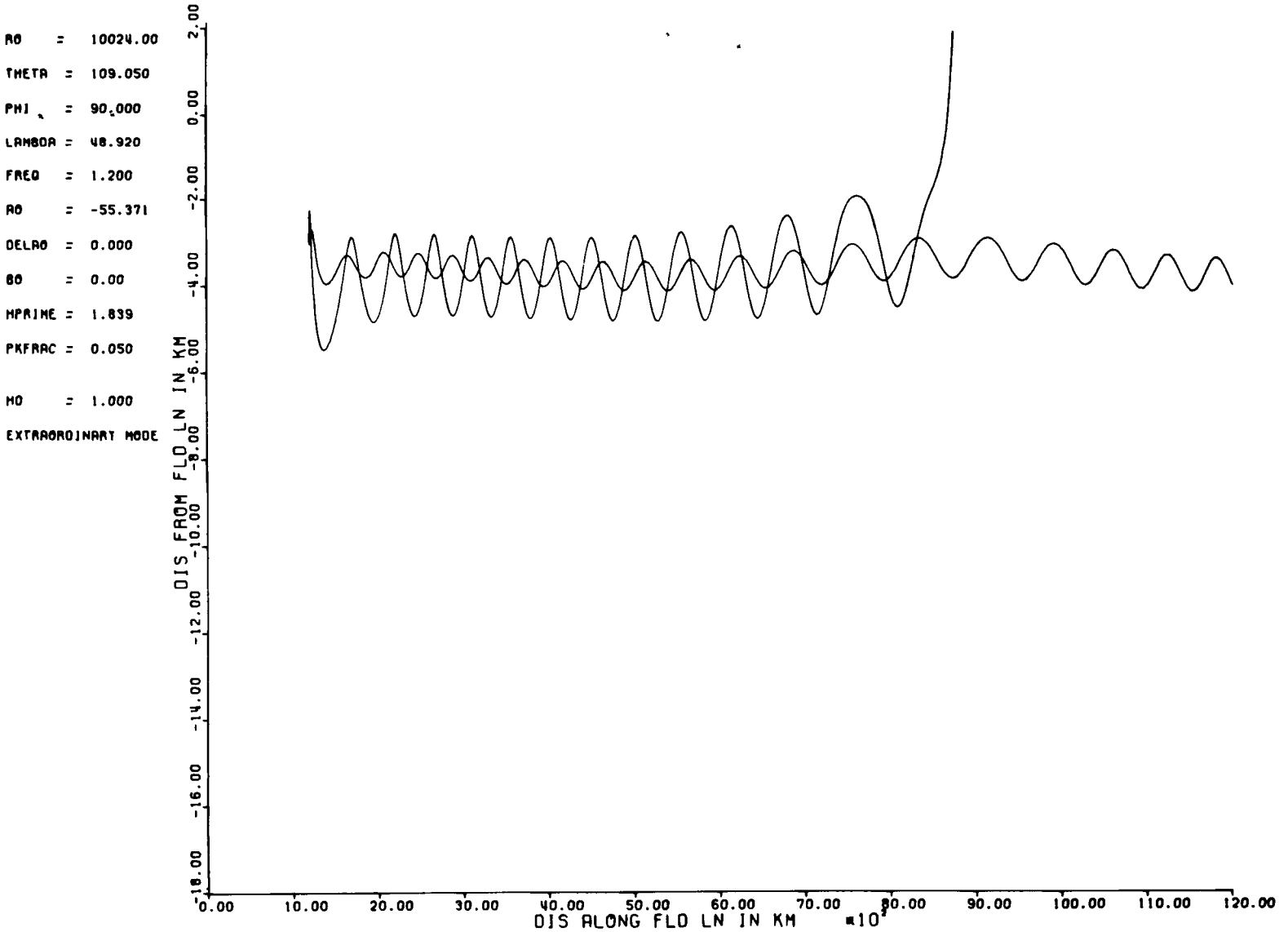


Figure 5A. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 5 Percent

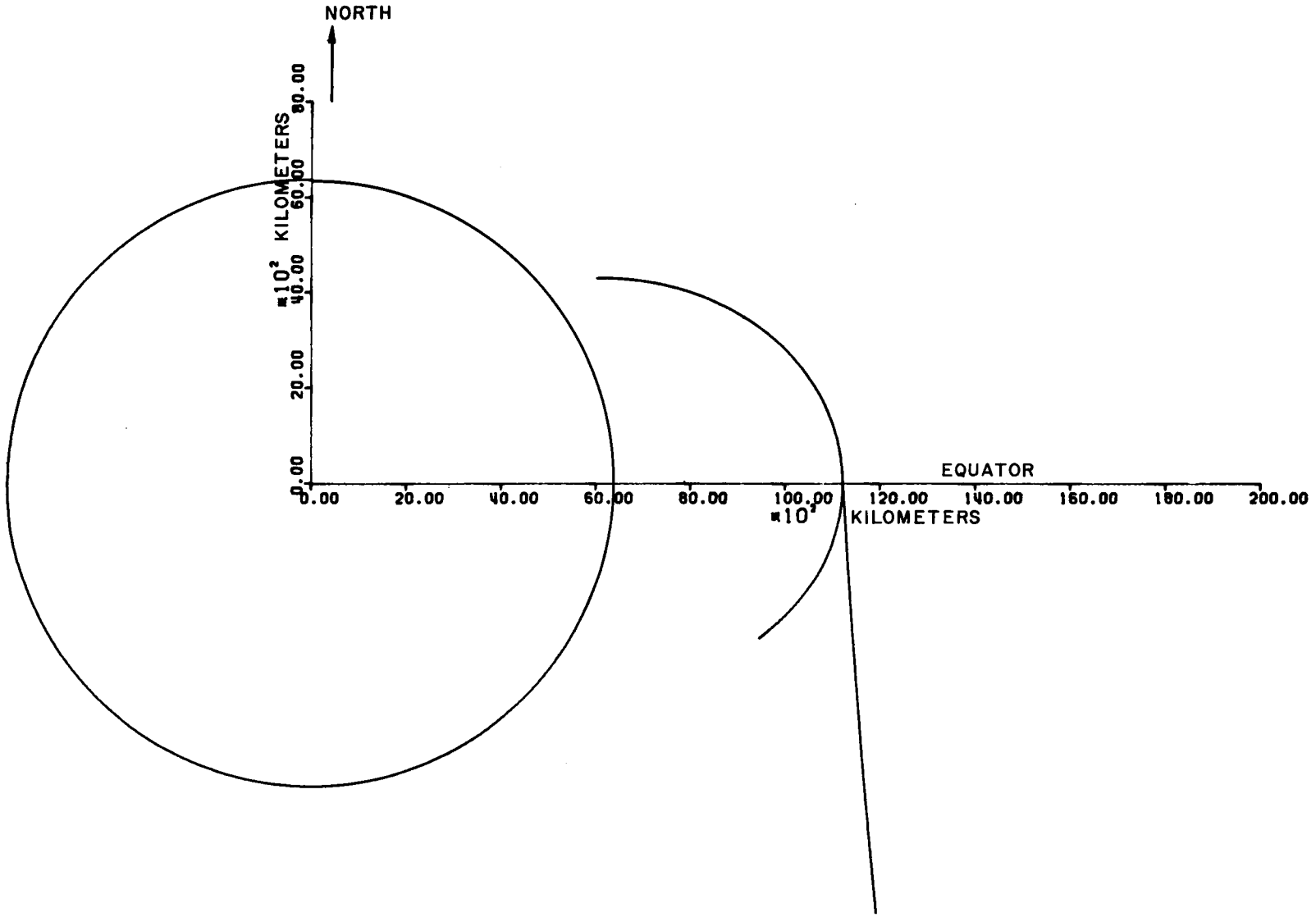


Figure 5B. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 5 Percent

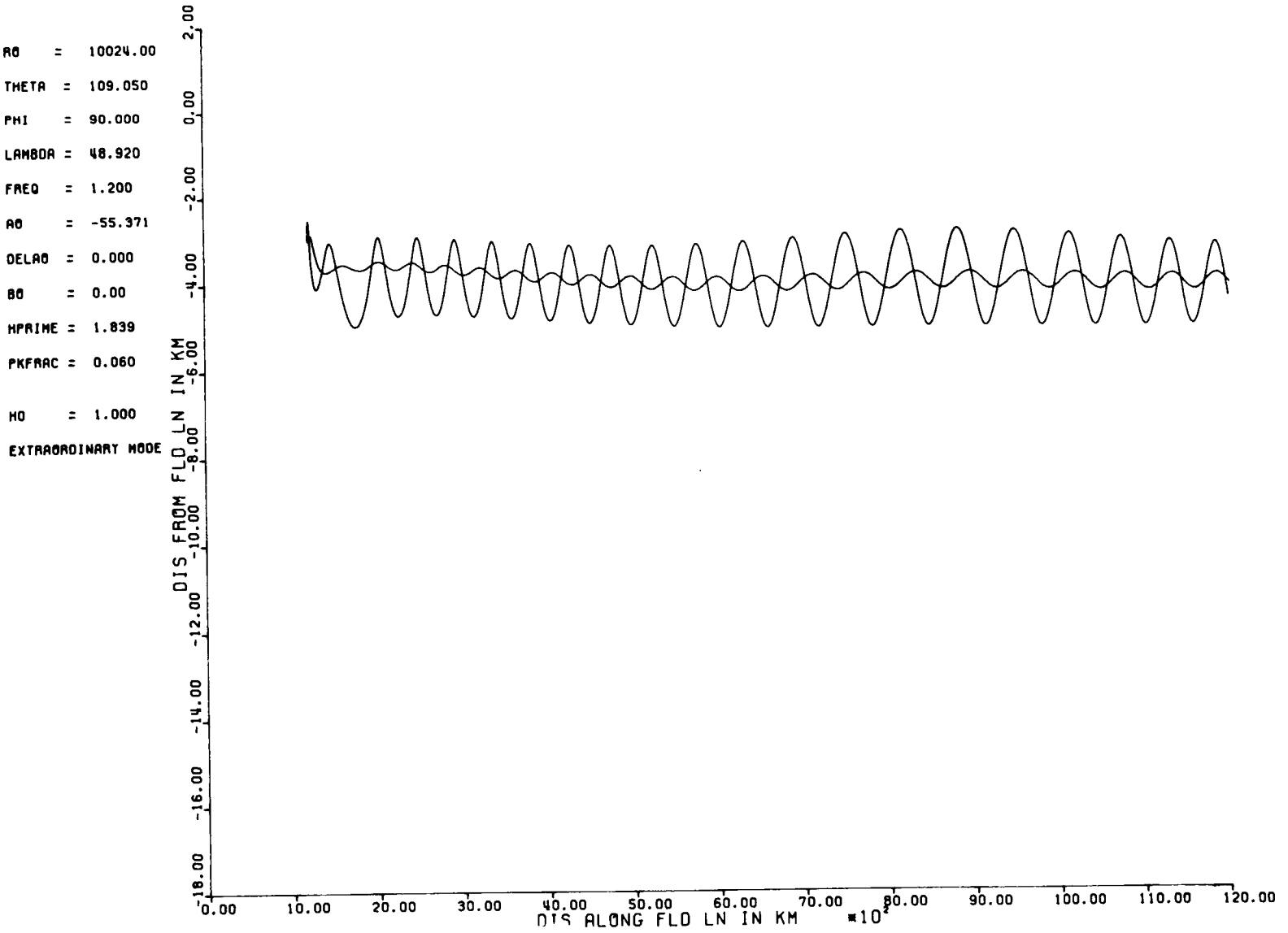


Figure 5C. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 5 Percent

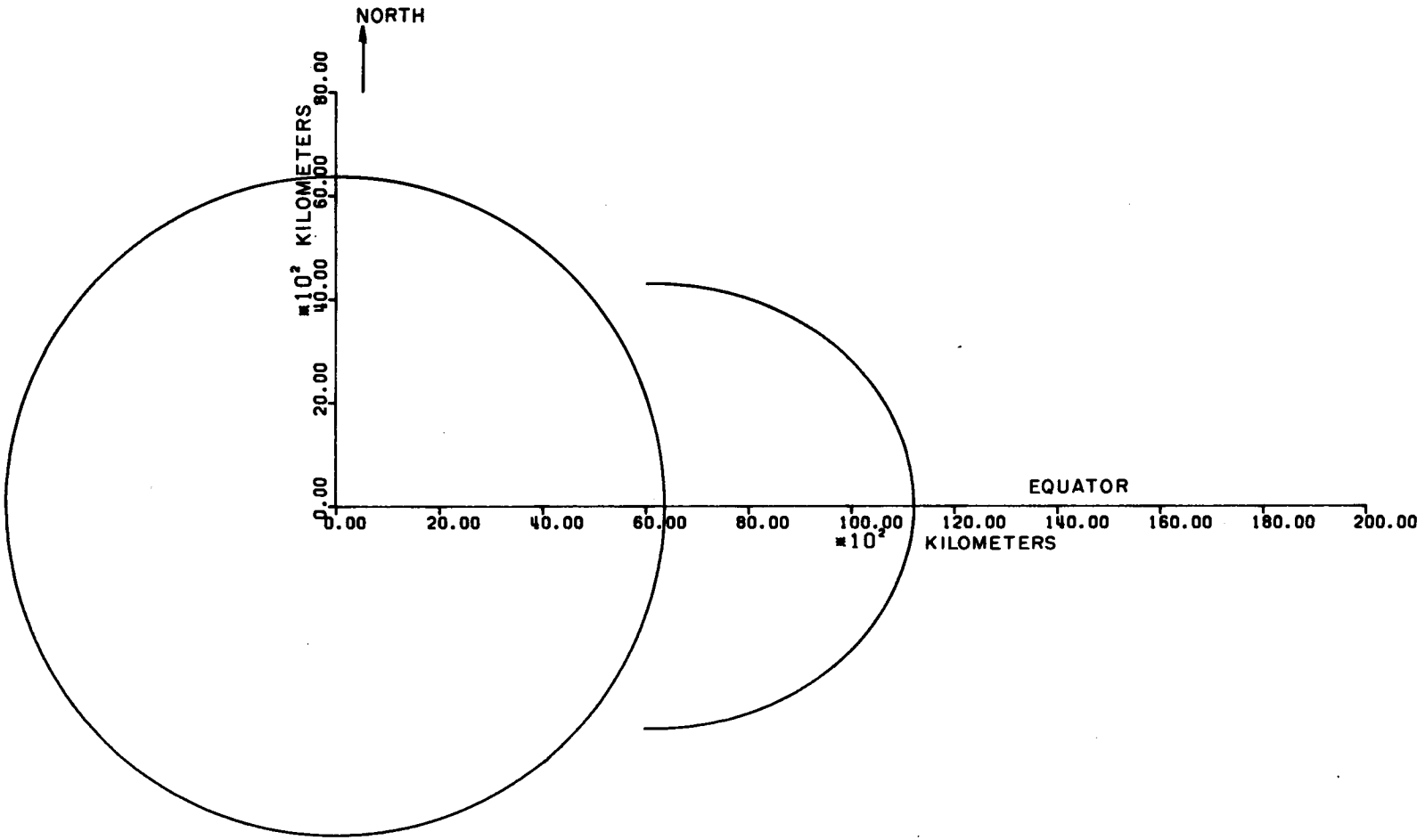


Figure 5D. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 6 Percent

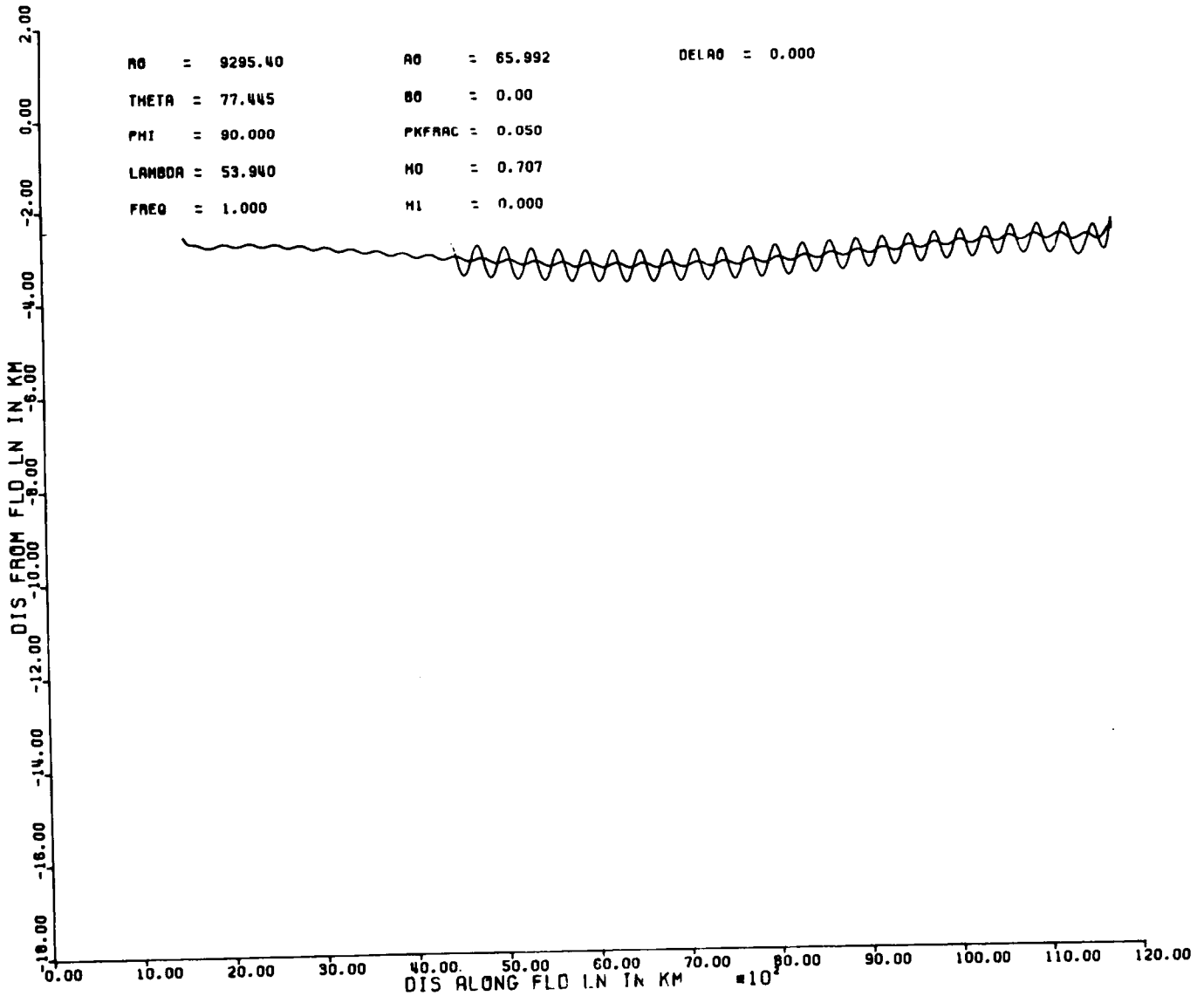


Figure 5E. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 7 Percent

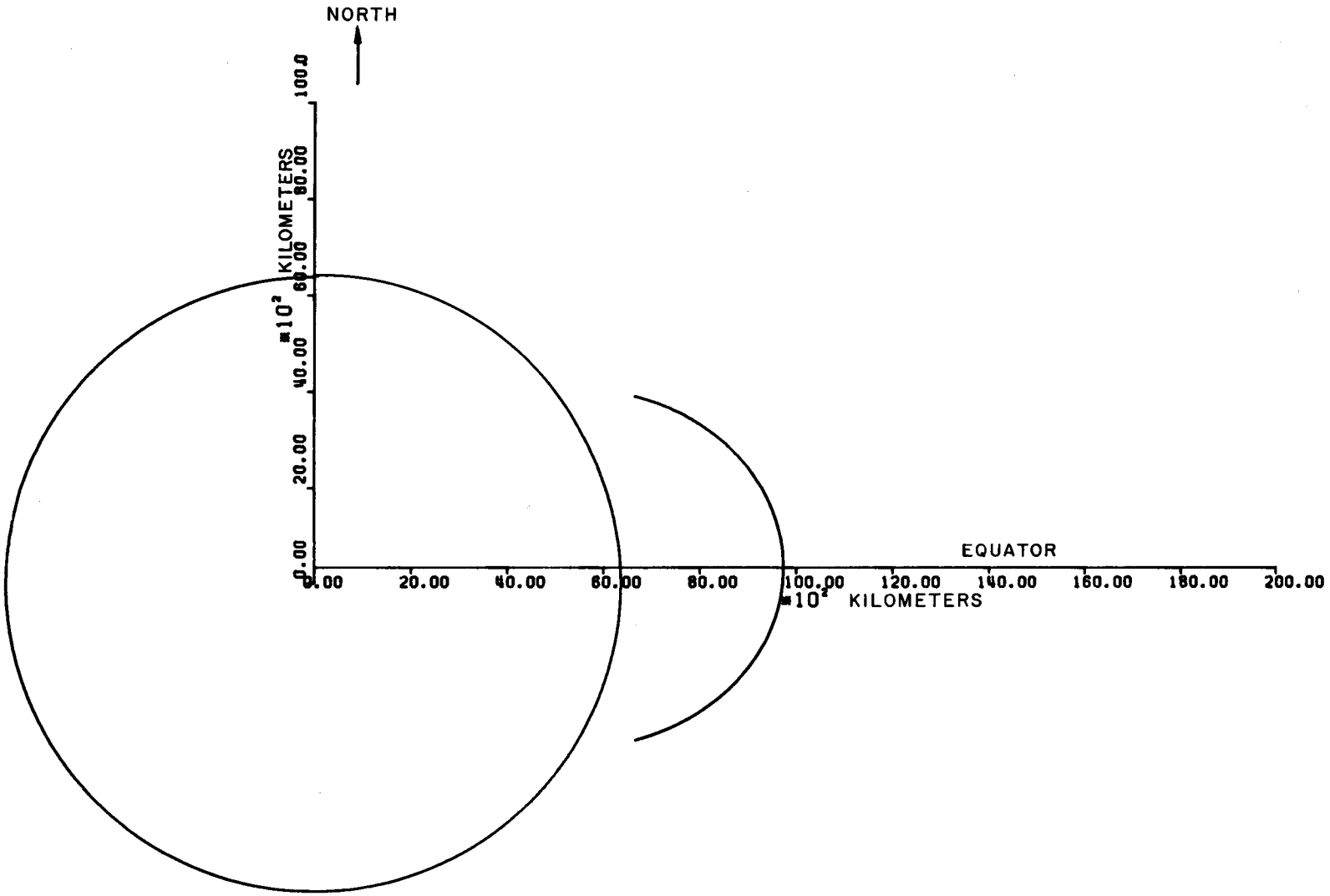


Figure 5F. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 7 Percent

But, the dipole model is highly idealized and lacks such features as local variations in the magnetic field strength. Its advantage lies in the fact that it saves a lot of computer time and for the ray-tracing problem under study, the microscopic features of the magnetic field are not necessary.*

Collision frequency model.- The collision frequency model has the following functional form:

$$\nu = 10^{\nu'}$$

where ν' is computed as shown below. The collision frequency profile as a function of altitude consists of three parts that are smoothly joined with the aid of a curve fitting program.

for $6378 \leq r \leq 6478$ km:

$$\nu' = 12.03527 - 0.07392\, x$$

where $x = (r-6378)$km.

for $6478 \leq r \leq 6853$ km:

$$\nu' = \sum_{i=1}^{6} \left[a_i + C(\theta, \phi) b_i \right] f_i(x)$$

where

$f_1(x) = 1$; $x = (r-6478)$km

$f_2(x) = x$

$f_3(x) = x^2$

$f_4(x) = x^3$

$f_5(x) = \cos(0.0157x)$

*Those who are interested in using a better magnetic field model should refer to Langworthy (Smith) (1966) for a description of the Gaussian spherical harmonic magnetic field model.

$$f_6(x) = \sin(0.0157x)$$

$a_1 = 5.0562$; $b_1 = 0.032512$

$a_2 = -3.7482\text{x}10^{-2}$; $b_2 = -0.8847\text{x}10^{-2}$

$a_3 = 1.3864\text{x}10^{-4}$; $b_3 = 0.8541\text{x}10^{-4}$

$a_4 = 1.4777\text{x}10^{-7}$; $b_4 = -1.5422\text{x}10^{-7}$

$a_5 = -0.48192$; $b_5 = 0.01470$

$a_6 = -0.27021$; $b_6 = 0.65037$

$$C(\theta, \phi) = C_1\theta^2 + C_2\theta + C_3 + (d_1\theta^2 + d_2\theta + d_3)\cos\phi$$

where

$C_1 = -0.35818$; $d_1 = -0.17828$

$C_2 = 1.1250$; $d_2 = 0.55997$

$C_3 = -0.88344$; $d_3 = 0.56028$

θ is the colatitude and ϕ is the longitude in degrees. Symbol $\phi = 0$ corresponds to local noon.

For $r \geq 6853$ km,

$$\nu' = 2.3653\text{-}0.0030266x + (0.3195\text{-}0.0000536x)\, C(\theta, \phi)$$

where

$$x = (r\text{-}6853)$$

Electron density model.- The model for the electron density distribution incorporates those features that have a bearing on the high-frequency ducting problem. Thus, an ionization irregularity (duct) model is superimposed on the normal radial distribution of electron density. The duct structure is aligned along the magnetic field.

A complete description of the electron density model can be found in section III.

Integration Package

Because of the high accuracy obtainable, the use of a digital computer is preferred to an analog machine for the integration of the ray equations. The method used solves the first n of a set, N, of first-order differential equations simultaneously. The Adams-Moulton open and/or open and closed formulas are used. A Runge-Kutta fourth-order integrator is used as a starting routine to generate the necessary differences. Provision is made for interrupting the integration process at specific values of either the independent or dependent variables. The order of differences used in the Adams-Moulton mode is less than or equal to nine.

A complete description of the integration package is found in Appendix A.

II. USER'S MANUAL

Introduction

This User's Manual is intended to supply all the information and guidelines necessary for a non-programmer to operate the ray-tracing program.

Inputs

In order to facilitate using this program, the NAMELIST feature of FORTRAN IV is used. This input mode has two distinct advantages over a fixed format statement:

(1) It minimizes keypunching errors

(2) When stacking cases, it minimizes the size of the input deck

NAMELIST allows for a free format input stream; the data can be placed anywhere on the card and spaced in any convenient manner. The basic rules the user must keep in mind when constructing an input deck are outlined in section III. For a detailed description of the NAMELIST feature see IBM form C28-6390.

IBM 7090-7094 IBSYS operating system, version 13, FORTRAN IV language.- It has been found that when stacking data sets for running as many cases as possible, there is usually some similarity among sucessive sets. NAMELIST allows the user to take maximum advantage of any similarity.

The first data set in the stack must contain all data required by the program for normal operation. Each successive data set, however, must specify only those parameters whose values differ from immediately preceding case.

We consider the input data to be of three distinct types:

(1) Data which is required for the normal operation of the program and must be supplied by the user

(2) Optional integration control parameters

(3) Optional plotting limits

Detailed descriptions of these three data types can be found in the following paragraphs.

Input dictionaries.- The input is under control of three dictionaries. The first dictionary, XNAME1, refers to the required program inputs. The remaining dictionaries, XNAME3 and XNAME5, refer to the optional integration and plot parameters, respectively.

Required input - XNAME1.- Figure 6 shows a sample input deck for the required inputs. The dictionary for these inputs consists of five names: D, LAST, NTITLE, NCONST, and LIMITS. The first name, D, is a 28-word array containing all the data about the initial position of the ray, direction and ray characteristics. The four remaining names are single word indicators. An explanation of each of the required inputs follows.

D array.- Table II contains an item by item description of each of the parameters in the D array. The subscript shown in the left-hand column indicates the position in the array. The subscript of the first item must be punched and then the remaining items will be stored sequentially. Figure 7 is a graphical illustration of the initial ray-position input parameters specified by D(1) through D(6).

TABLE II

D ARRAY

D	DESCRIPTION
1	Initial geocentric radius, r_o, in kilometers
2	Initial colatitude, θ_o, in degrees. $(0 \leqslant \theta \leqslant 180)$
3	Initial longitude, ϕ_o, in degrees. $(0 \leqslant \phi \leqslant 360)$
4	Initial ray angle, A_o, with respect to the local vertical, in degrees. $(0^o \leqslant A_o \leqslant 180^o)$ NOTE A_o is no longer a program input. A_o is calculated from ΔA_o. However, the location D(4) is still reserved for A_o.
5	Initial ray angle, B_o, with respect to the south vector, in degrees. $(0^o \leqslant B_o \leqslant 360^o)$
6	Initial ray angle, ΔA_o, with respect to the tangent of the field line in degrees. $(0 \leqslant \Delta A_o \leqslant 180^o)$
7	Maximum allowable geocentric radius, R_{max}, in kilometers

TABLE II.- Continued

D ARRAY

D	Description
8	Minimum allowable geocentric radius, R_{min}, in kilometers
9	Maximum allowable colatitude, θ_{max}, in degrees. ($0^{o} \leqslant \theta_{max} \leqslant 180^{o}$)
10	Minimum allowable coatitude, θ_{min}, in degrees. ($0^{o} \leqslant \theta_{min} \leqslant 180^{o}$)
11	Maximum allowable longitude, ϕ_{max}, in degrees. ($0^{o} \leqslant \phi_{max} \leqslant 360^{o}$)
12	Minimum allowable longitude, ϕ_{min}, in degrees. ($0^{o} \leqslant \phi_{min} \leqslant 360^{o}$)
13	Print interval in kilometers. Printed output is keyed to phase path length
14	Plot interval in kilometers. Plotted output is keyed to phase path length. It has nothing to do with the Print Interval. It is only a control of the spacing of the points to be plotted.
15	Nominal integration step size, in kilometers. Integrations are with respect to phase path length
16	Wave frequency, F, in megacycles per second
17	Ray type indicator: Set equal to 1 for ordinary type, or Set equal to -1 for extraordinary type
18	Reflection indicator: Set equal to 2 if reflection is desired, 0 otherwise. Ordinarily, reflection occurs whenever the rate of change of geocentric radius goes to zero
19	Powerloss calculation indicator: Set equal to 1 if computation is desired, 0 otherwise

TABLE II.- Concluded

D ARRAY

D	Description
20	Plot option indicator: Set equal to 1 if plotting is desired, 0 otherwise
21	Plot overlay option indicator: Set equal to 1 if overlaying of successive plots is desired, 0 otherwise. Ignored if NPLOT = 0
22	Automatic positioning of ray at point of maximum electron density gradient indicator: Set equal to 1 if automatic positioning is desired, 0 otherwise
23	Scale size of the ionization irregularity at the base of the field line H_o
24	Peak fractional enhancement at (r_o, θ_o, ϕ_o) where r_o is the initial geocentric radius, θ_o is the initial colatitude and ϕ_o is the initial longitude
25	Colatitude, λ, in degrees of the field-line passing through the initial ray position.
26,27,28	Not used

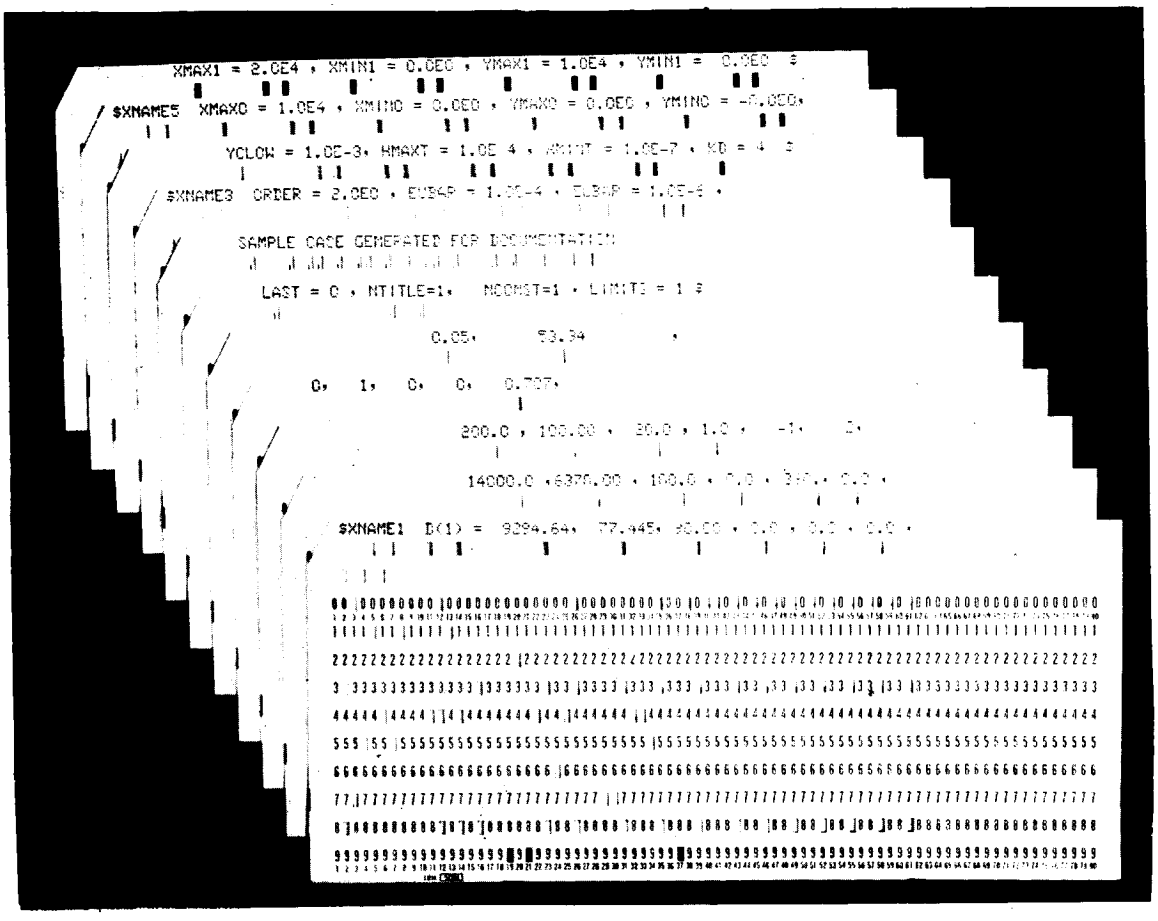


Figure 6. - Sample Deck Setup

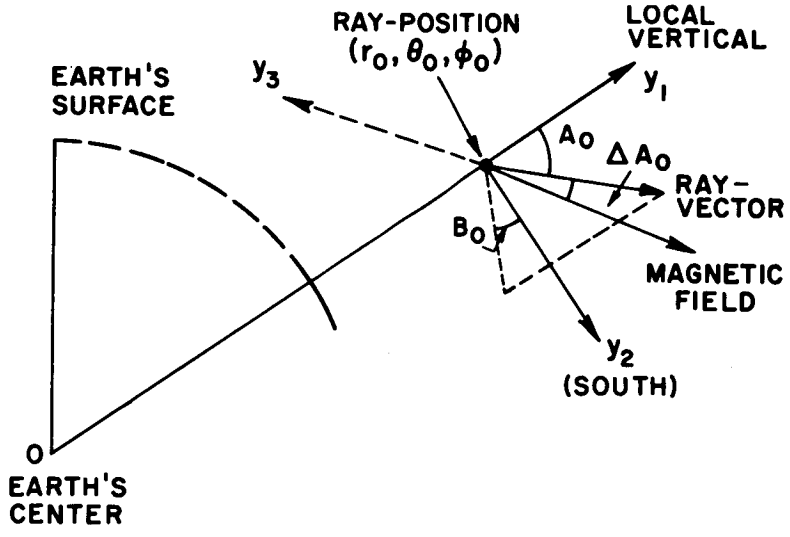


Figure 7. - Initial Ray - Position Inputs

Required indicators.- The remaining inputs under control of XNAME1 are four indicators described in Table III.

TABLE III

REQUIRED INPUT INDICATORS

Name	Description
LAST	Last Case Indicator: The program assumes LAST = 0, so the last case to be executed must explicitly set this parameter to 1
NTITLE	Optional Title Information: NTITLE preset to 0. If some identification is to be printed, set NTITLE = 1
NCONST	Optional Input Indicator, Integration Parameters: The program assumes NCONST = 0. If the integration parameters are to be changed, set NCONST = 1
LIMITS	Optional Input Indicator, Plotting Limits: The program assumes LIMITS = 0. If the plotting limits are to be changed set LIMITS = 1

Optional input.- The parameters described here are preset by the program. However, the user can replace any subset of these parameters by setting the values of NCONST and/or LIMITS equal to 1 and then punching a set of data cards using the dictionary XNAME3 and/or XNAME5. These cards must follow the statement card if NTITLE = 1 or immediately following the required inputs if NTITLE = 0.

Integration parameters - XNAME3.- The optional integration parameters are under control of the dictionary XNAME3. The dictionary contains seven names representing seven data items. Table IV defines each parameter and gives its nominal value. Appendix A contains a description of the integration routine.

TABLE IV (XNAME3)

Integration Parameters

Name	Nominal Value	Description
ORDER	1.0	Precision option. When set to 0 the integration is carried out in partial double precision, set to 1.0 integration is performed in full double precision
EUBAR	1.0E-5	Maximum integration error. When the integration error is greater or equal to this value the integration interval is halved
ELBAR	1.0E-7	Minimum integration error. When the integration error is less than or equal to this parameter the integration step is doubled
YCLOW	1.0E.7	Minimum value of the dependent variable. If the dependent variable is less than or equal to this parameter no halving will take place
HMAXT	1.0E+4	Maximum integration step. The integration step is not permitted to exceed this value
HMINT	1.0E-7	Minimum integration step. The integration step is not allowed to be smaller than this input
KD	4	Type of integration (must always equal 4)

Plot limits (XNAME5).- The optional plot limits are under the control of dictionary XNAME5. This dictionary contains eight names. Table V defines each limit and its nominal value.

TABLE V (XNAME5)

PLOT LIMITS

Name	Nominal Value	Description
XMINO	0.0	Minimum value of the X-axis for the rectangular plot.
XMAXO	1.20E4	Maximum value of the X-axis for the rectangular plot.
YMINO	-18.0	Minimum value of the Y-axis for the rectangular plot.
YMAXO	+2.0	Maximum value of the Y-axis for the rectangular plot.
XMIN1	0.0	Minimum value of the X-axis for the Polar Plot.
XMAX1	2.0E4	Maximum value of the X-axis for the Polar Plot.
YMIN1	0.0	Minimum value of the Y-axis for the Polar Plot.
YMAX1	1.0E4	Maximum value of the Y-axis for the Polar Plot.

Input conventions.- The following is a listing of a few simple rules the user must keep in mind when constructing an input deck:

1. Column 1 of each input card is not to be used. Any information punched in this column will be ignored.

2. The first character encountered by the input system must be a dollar sign ($) punched in column 2 of the first card of each group of inputs.

3. All data must be separated by commas. The input system assumes that any single input quantity must lie between an equal sign and a comma, or between two commas.

4. All numerical data can be entered in either a fixed decimal or exponential format. Whenever a decimal point does not appear within a number, in the case of the fixed decimal format, the system assumes that it is in front of the separator and all trailing blanks (i.e., no punches) will be

converted to zeroes. In the case of the exponential format the decimal point is assumed to lie to the right of the least significant digit. As an illustration, the following list of numbers will have identical binary representations in core storage:

```
2500.0
25bb        fixed decimal (b-blank, no punch)

25E+2
2.5E+3      exponential format
```

Note that in the above illustration the exponent is separated from the significant part of the number by the letter E.

5. The NAME LIST system allows for continuation cards. If continuation cards are used then the user must be careful in placing the input cards in proper order. When using continuation cards the name of the table, (array) need not be repeated. The only limitations are that column 1 is not to be used and each card must end with a comma.

   This program allows the user to execute several cases within a single run. This is done by first setting the indicator, NA, equal to zero within the first set of input and then for each of the following cases simply punch the dictionary name with the proper system symbols and then specify only those inputs which are to differ from the immediately preceding case. The inputs for each case are then placed behind each other, no separator cards are required, and the resulting input deck is placed behind the binary deck as described earlier.

6. The end of an input string is indicated by a dollar sign ($). The input system will continue reading until the second dollar sign is encountered.

Operating Instructions

Deck setup.- The following is a list of the control cards necessary to compile and execute the program in source form:

```
CC          CC          CC
 1           8          16

     $JOB D3121A 1 ERC J. Ramasastry - TRACE
     $EXECUTE       IBJOB
     $IBJOB         FIOCS
```

```
$IBFTC MAIN
                MAIN PROGRAM          (SOURCE)
$IBFTC INPU
                SUBROUTINE INPUT      (SOURCE)
$IBFTC OUTPU
                SUBROUTINE OUTPUT     (SOURCE)
$IBFTC FIEL
                SUBROUTINE FIELD      (SOURCE)
$IBFTC DENS
                SUBROUTINE DENSE      (SOURCE)
$IBFTC COL
                SUBROUTINE COLL       (SOURCE)
$IBFTC CALCO
                SUBROUTINE CALCO4     (SOURCE)
$IBFTC SCA
                SUBROUTINE PRAM       (SOURCE)
$IBFTC FORC
                SUBROUTINE FORCE      (SOURCE)
$IBFTC POLA
                SUBROUTINE POLAR      (SOURCE)
$IBFTC POWER
                SUBROUTINE POWERL     (SOURCE)
$IBFTC MARS
                SUBROUTINE MARK       (SOURCE)
$IBFTC SMK2
                SUBROUTINE SMARK      (SOURCE)
```

```
$IBFTC CST

                SUBROUTINE CSINT      (SOURCE)

$IBFTC MIN

                SUBROUTINE MINV       (SOURCE)

$IBFTC TO

                SUBROUTINE TOR        (SOURCE)

$DATA

 '              DATA DECK

 '      END OF FILE CARD
```

I/O assignments.- The program uses the standard ERC-IBM 7094-II assignments. The FORTRAN IV logical units are 5 and 6, respectively. If a plot is to be generated a tape must be mounted on SYSUT7.

Abnormal termination.- The program recognizes three types of abnormal terminations:

(1) An error in the integration routine. The message, ERROR RETURN FROM MARK is printed. The program will continue on to the next case.

(2) $\mu^2 \leqslant 0$

The message, THE VALUE OF EMUS IS NEGATIVE is printed. The program will continue on to the next case.

(3) $1 - x \leqslant 0$

The message, THE VALUE OF TERM IS NEGATIVE is printed. The program will continue on to the next case.

III. PROGRAMMER'S MANUAL

Introduction

This Programmer's Manual contains all the technical information required by a programmer whose task it may be to modify the program.

Each subroutine is described separately. Each description generally consists of:

(1) The mathematical formulation of the computations

(2) A flow chart of the routine

(3) A dictionary of the FORTRAN variables calculated in the routine

Following the subroutine descriptions the labeled COMMON statements are correlated with the subroutines in which they are used.

Source statement lists of all the subroutines are provided in Appendix B.

Main Program

Description.- The main program, MAIN, serves as an executive routine. (See flow chart in Figures 8A to 8H.) The functions of MAIN are:

(1) Initialization of the integration routine

(2) Computation of the derivative box

(3) Handling of trigger stops

The integration routine has a return indicator, NRTN, which, when tested, determines the order of calculations.

Upon return from the integration routine, the variable NRTN is set to an integer value from 1 to 5. NRTN is used to control program flow. Table VI indicates the action taken when NRTN assumes a particular value.

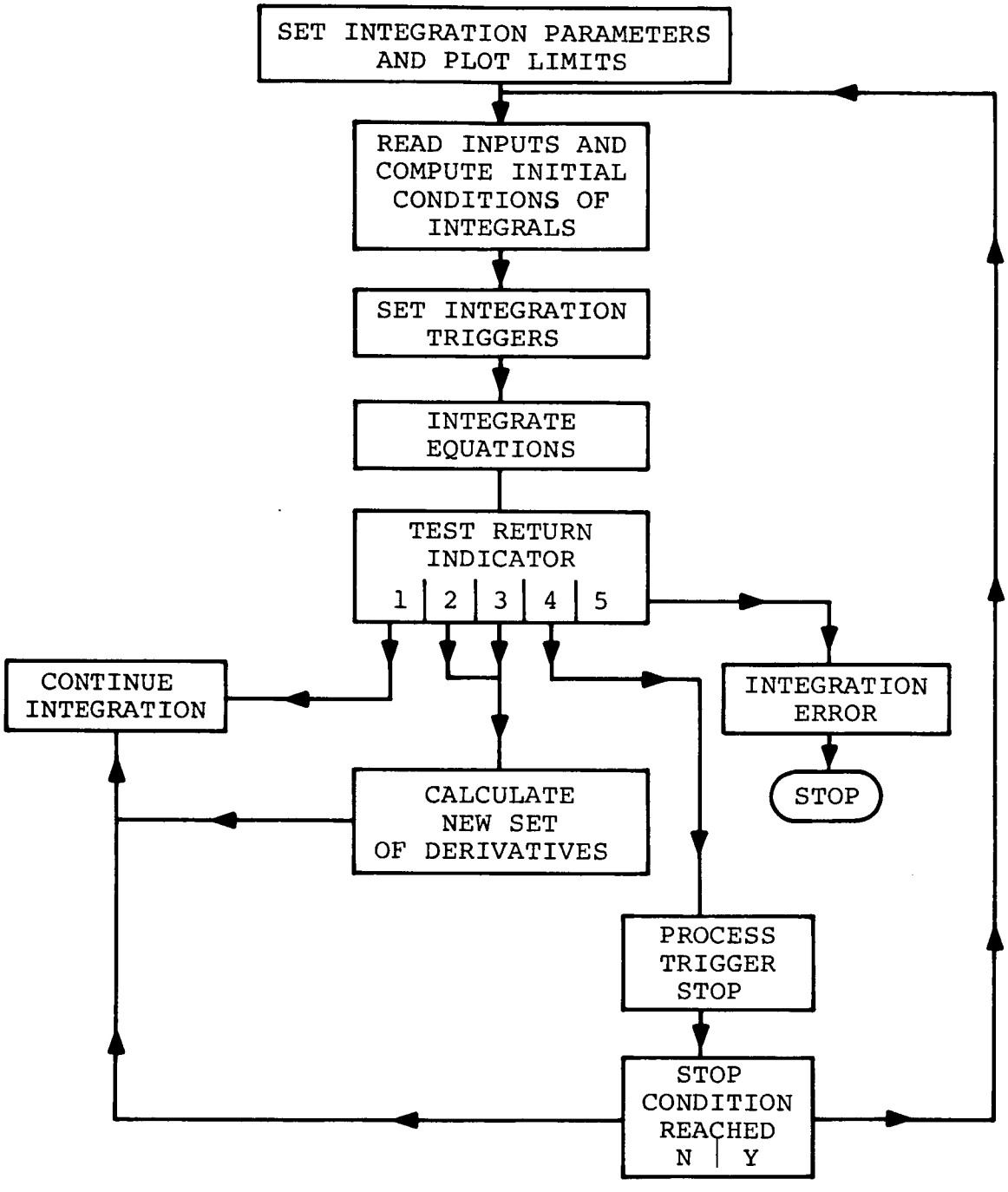


Figure 8A. - Flow Chart of Main Program

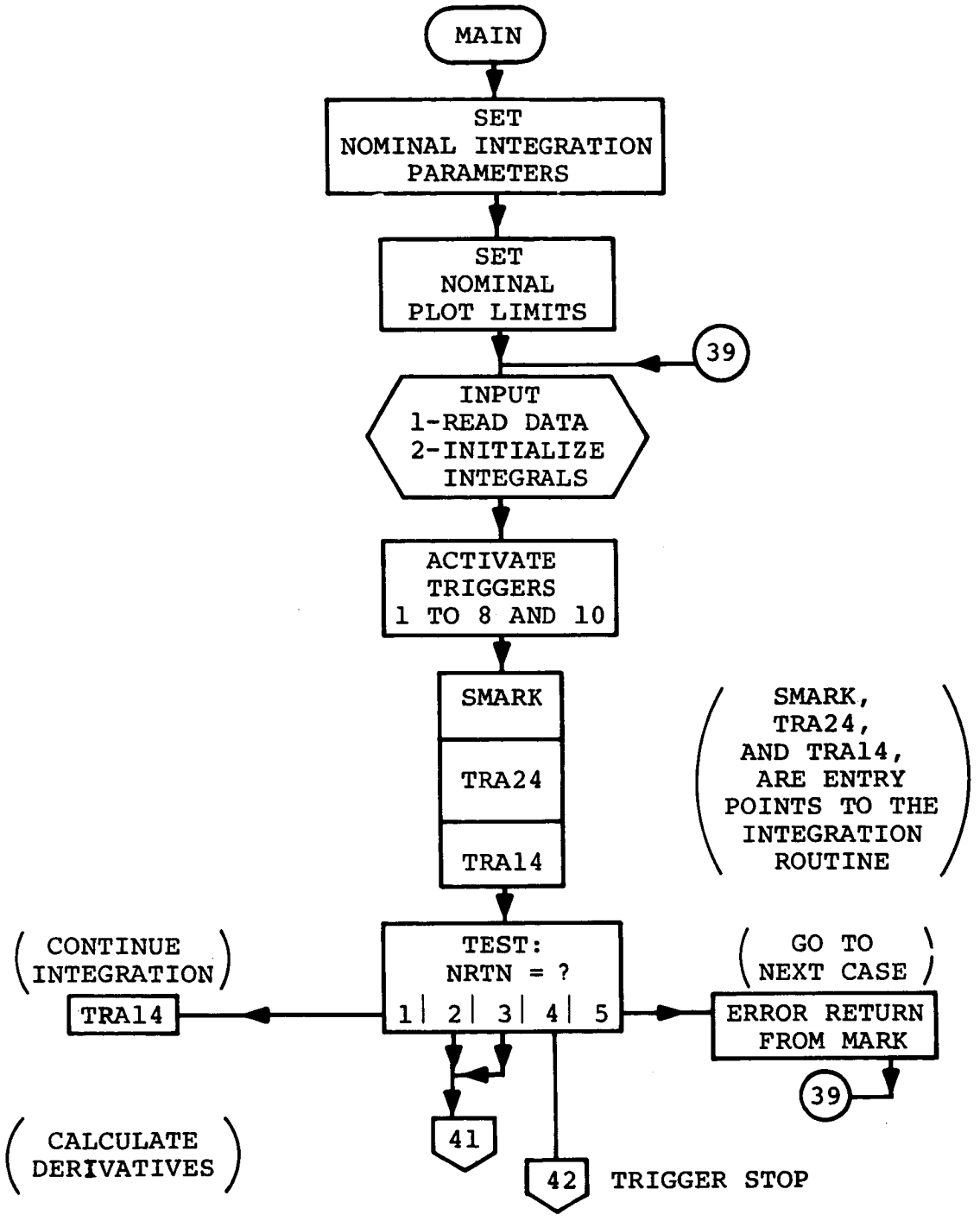


Figure 8B. - Flow Chart of Main Program

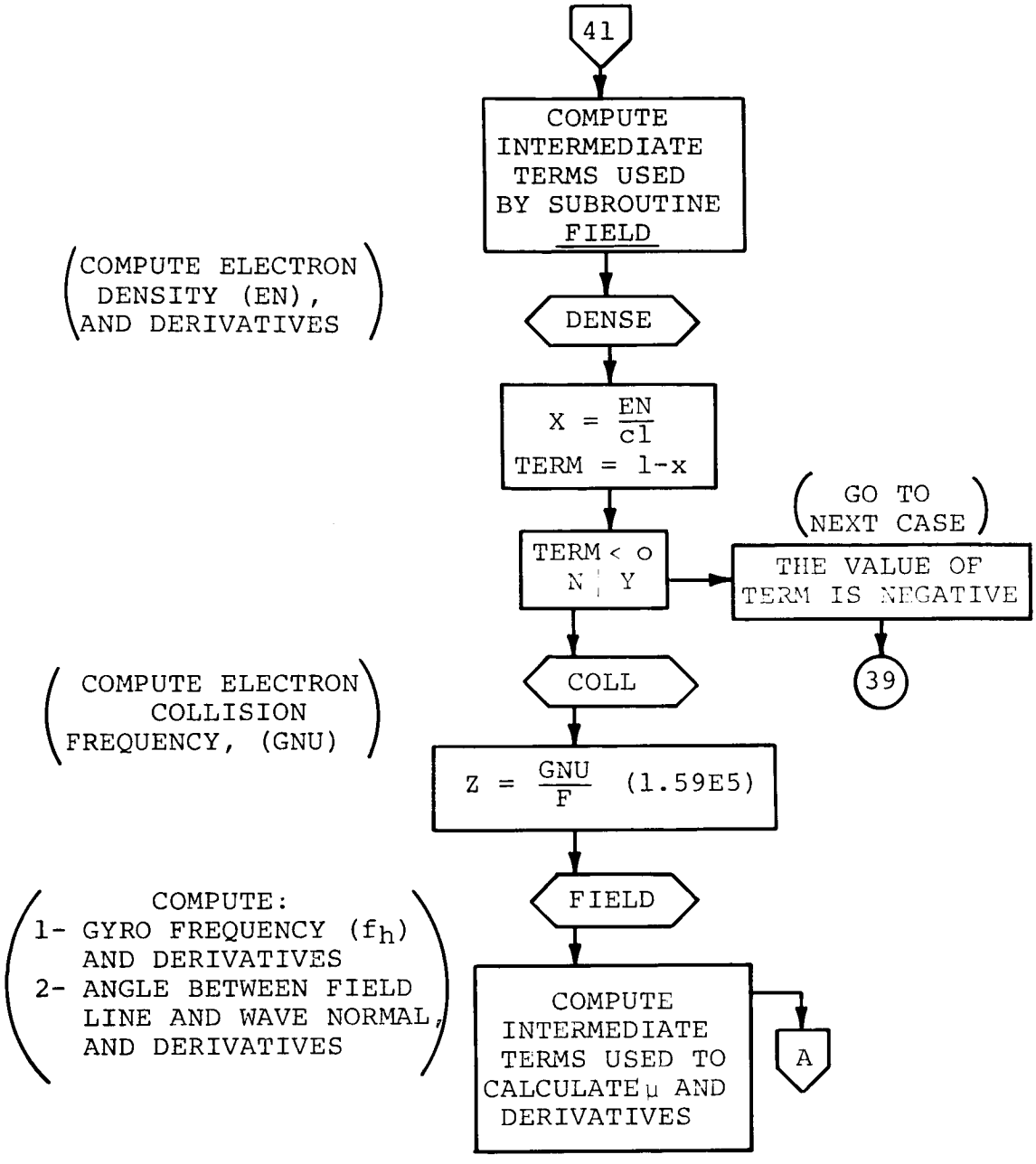


Figure 8C. - Flow Chart of Main Program

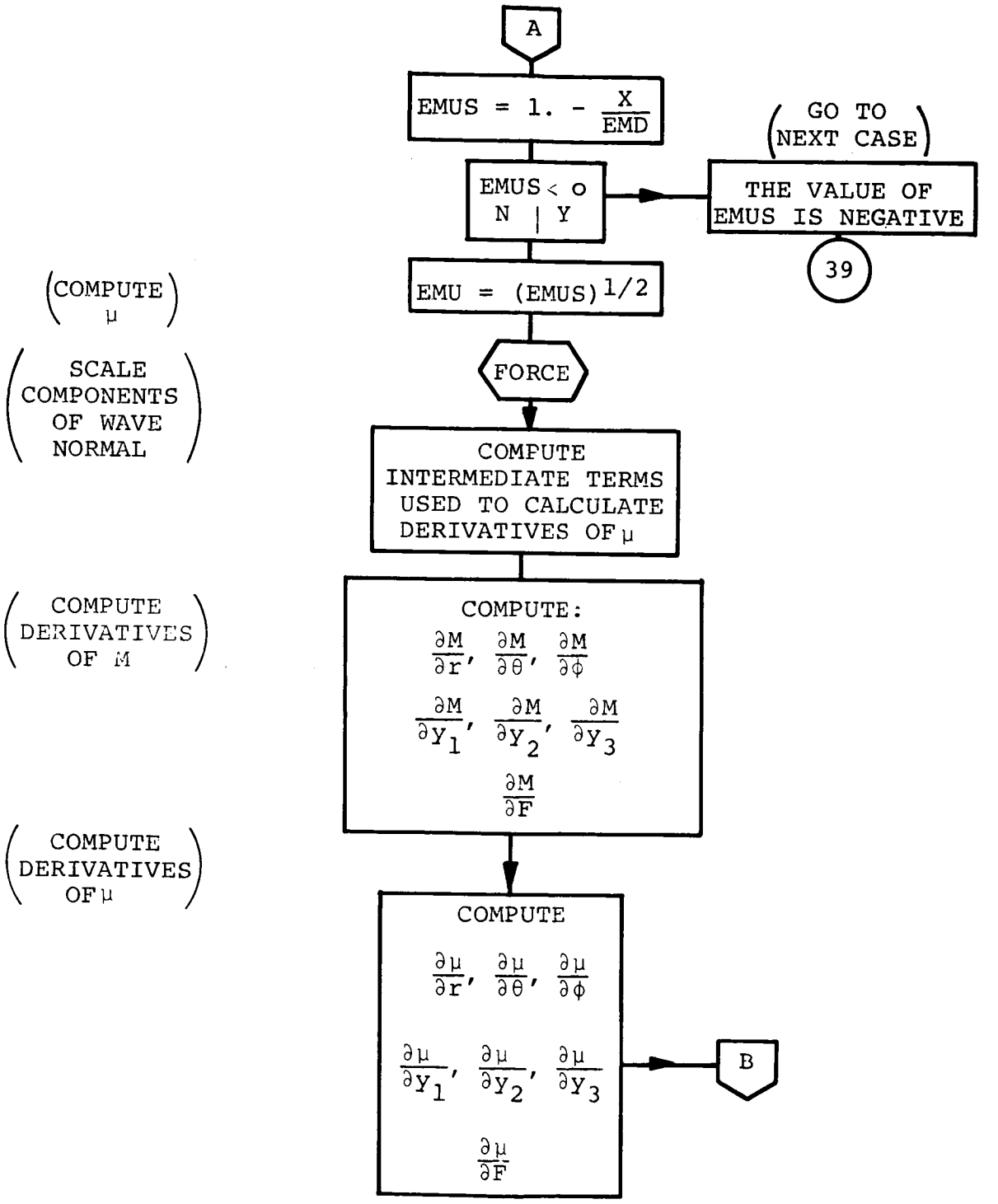


Figure 8D. - Flow Chart of Main Program

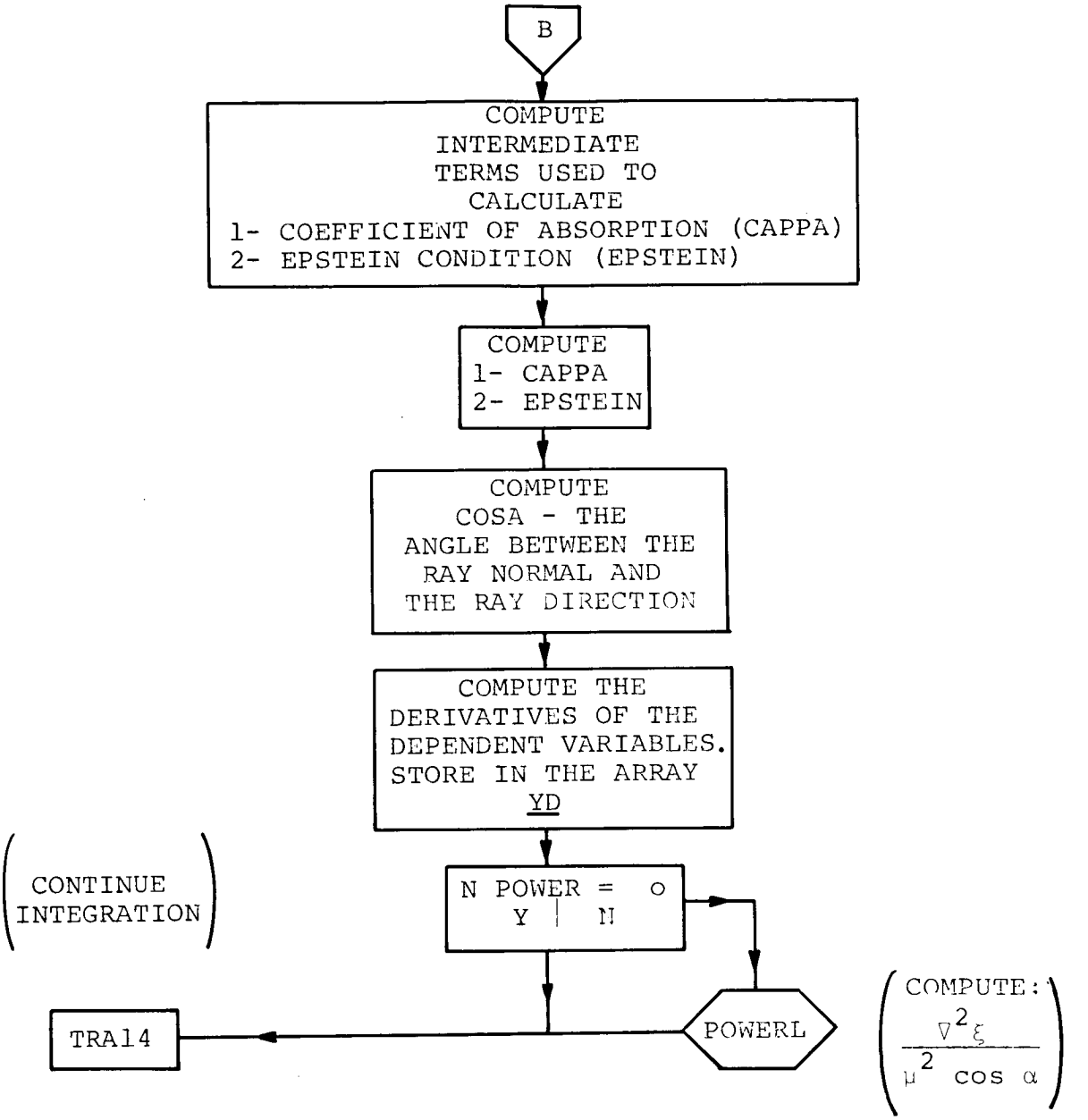


Figure 8E. - Flow Chart of Main Program

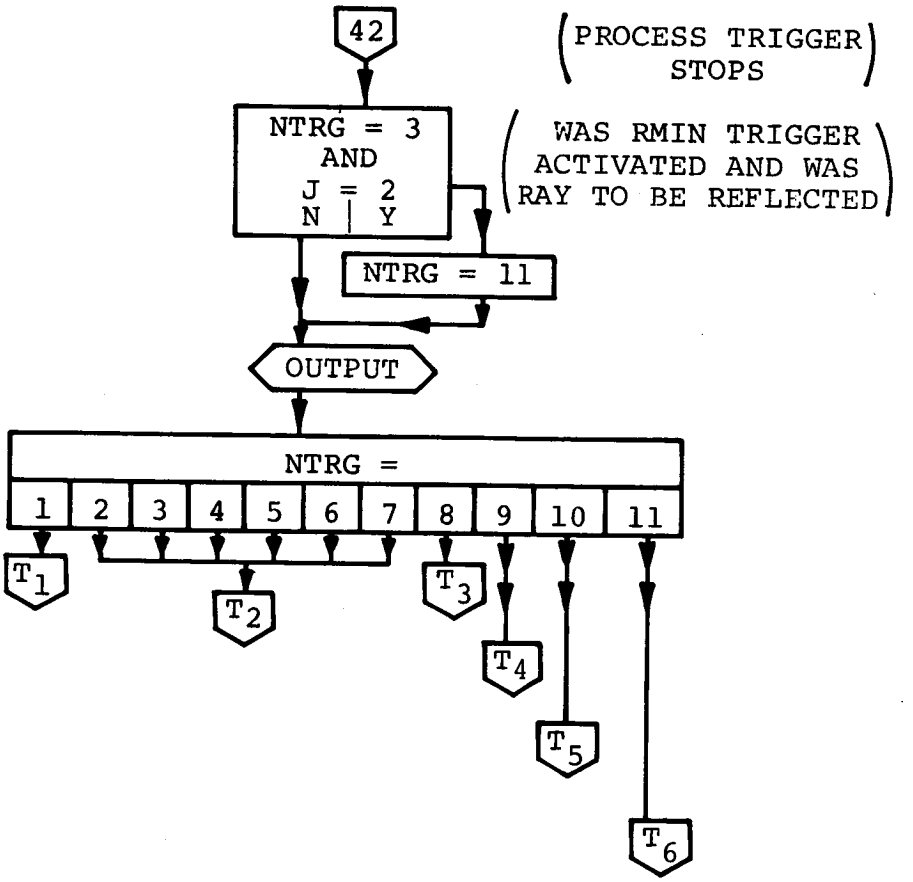


Figure 8F. - Flow Chart of Main Program

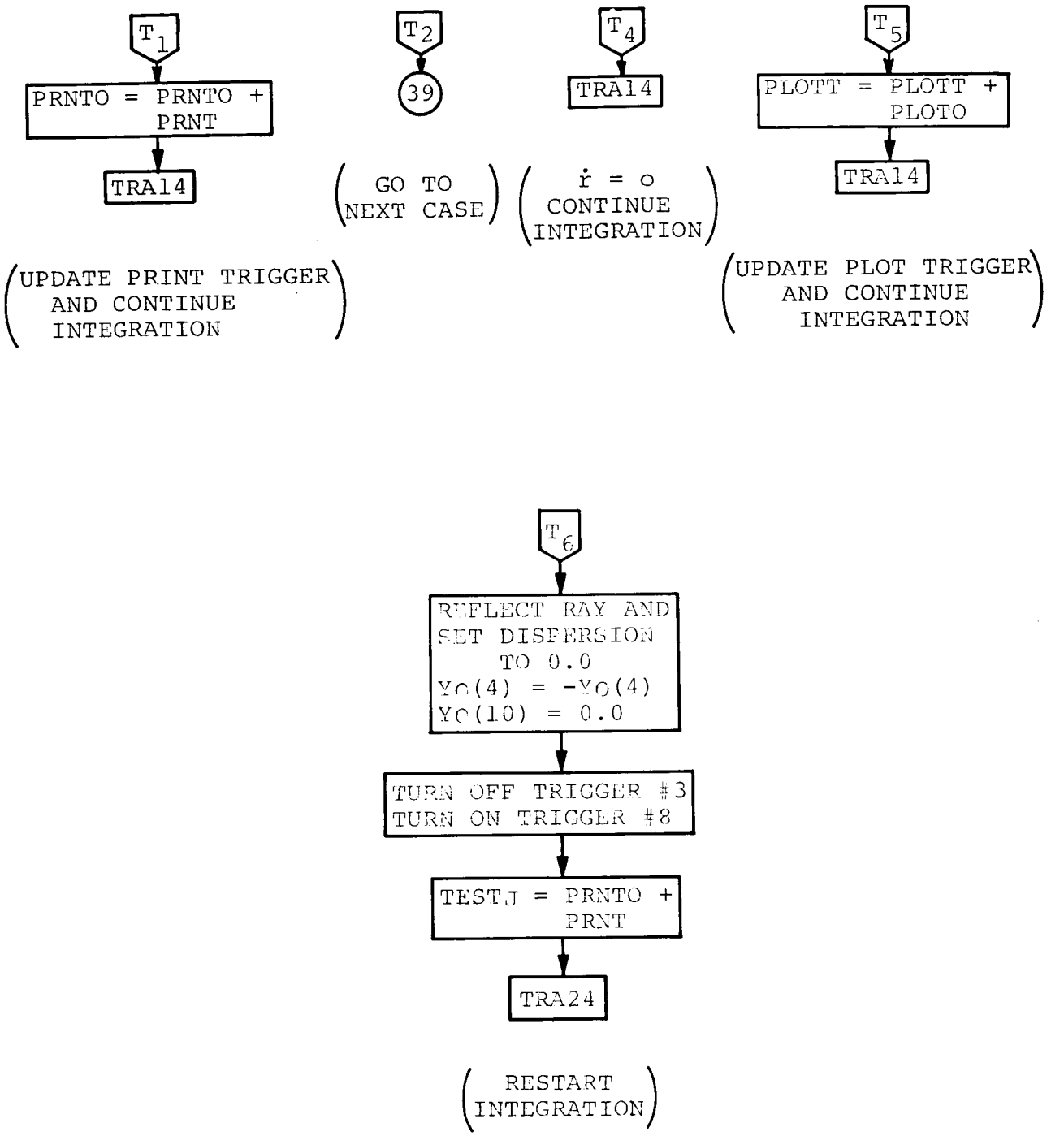


Figure 8G. - Flow Chart of Main Program

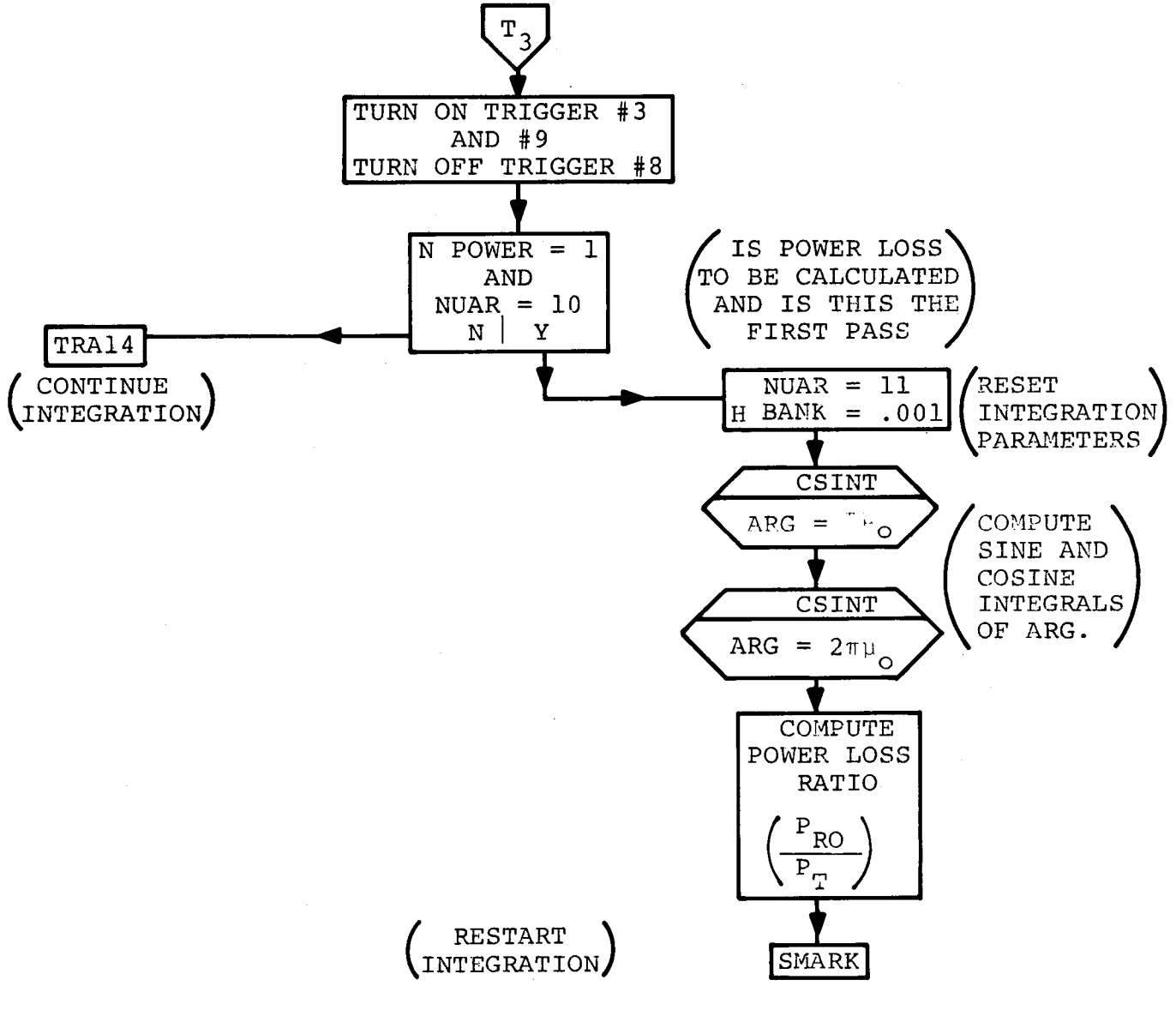


Figure 8H. - Flow Chart of Main Program

TABLE VI

ACTION TAKEN WITH REFERENCE TO RETURN INDICATOR

NRTN	
1	Return control to the integration routine.
2	Transfer control to DER1, the derivative box inclusive of any calculations which involve the independent variable.
3	Transfer control to DER2, the derivative box exclusive of any calculations which involve the independent variable. NOTE In this application, the independent variable is never used explicitly so for NRTN = 2 and NRTN = 3, control is transferred to DER2.
4	A trigger stop has occurred, process trigger stop.
5	An error has occurred during integration. The message ERROR RETURN FROM MARK will be printed and the program will stop.

Trigger stops are used to interrupt the integration routine at predetermined points. This program uses ten triggers. If a trigger stop occurs (i.e., NRTN = 4), the trigger indicator, NTRG, is set to an integer value from 1 to 10. The value assumed by NTRG corresponds to the trigger activated by the integration routine, MARK.

Table VII correlates the value of NTRG, the trigger activated and the sequence of actions taken.

TABLE VII

SEQUENCE OF ACTIONS TAKEN WITH REFERENCE TO TRIGGER INDICATOR

NTRG	
1	Print interval: call OUTPUT to print data, update trigger, return control to MARK.
2	The geocentric radius, r, has reached R_{max}: call OUTPUT to print data, if NPLOT $\geq$ 0 plot data, print end of case message, call INPUT to process next case.
3	The geocentric radius, r, has reached R_{min}: if reflection indicator, JTEST, does not equal two, the procedure is the same as for NTRG = 2, if JTEST = 2, the ray is reflected from a plane perpendicular to $\vec{r}$ and control is returned to the integration routine.
4	$\theta \geq \theta_{max}$: the procedure is the same as for NTRG = 2.
5	$\theta \leq \theta_{min}$: the procedure is the same as for NTRG = 2.
6	$\phi \geq \phi_{max}$: the procedure is the same as for NTRG = 2.
7	$\phi \leq \phi_{min}$: the procedure is the same as for NTRG = 2.
8	Phase path, h_p, has reached a value indicated by TESTJ: the stop on TESTJ has two functions. The first is to delay the start of the power loss calculation until the ray has traveled enough to be considered in the far field. It also turns on the trigger for a reflection stop when the ray has gone a specified distance past the reflection.

TABLE VII.— Concluded

SEQUENCE OF ACTIONS TAKEN WITH REFERENCE TO TRIGGER INDICATOR

NTRG	
9	$\dot{r} = 0$: call OUTPUT to print data, and store current values of r, θ, and ϕ in plotting arrays, print value of r, return control to MARK.
10	Plot interval: store current values of r, θ, and ϕ in plotting arrays, update trigger, return control to MARK.

Differential equations evaluated in the MAIN PROGRAM.- The following equations form a closed system for tracing the rays. The ray is described in terms of position in spherical coordinates with the origin at the center of the Earth and in terms of the components of the wave normal, Y_1, Y_2, Y_3 in the r, θ, ϕ directions, respectively.

#1 $$\dot{r} = \frac{1}{\mu^2}\left(Y_{1N} - \mu\frac{\partial\mu}{\partial Y_1}\right) \quad ; \quad r(o) = r_o$$

#2 $$\dot{\theta} = \frac{1}{r\mu^2}\left(Y_{2N} - \mu\frac{\partial\mu}{\partial Y_2}\right) \quad ; \quad \theta(o) = \theta_o$$

#3 $$\dot{\phi} = \frac{1}{r\mu^2\sin\theta}\left(Y_{3N} - \mu\frac{\partial\mu}{\partial Y_3}\right) \quad ; \quad \phi(o) = \phi_o$$

#4 $$\dot{Y}_1 = \frac{1}{\mu}\frac{\partial\mu}{\partial r} + \dot{\theta}Y_2 + \dot{\phi}Y_3\sin\theta \quad ; \quad Y_1(o) = Y_{10}$$

$$\#5 \qquad \dot{Y}_2 = \frac{1}{r}\left[\frac{1}{\mu}\frac{\partial\mu}{\partial\theta} - \dot{r}Y_2 + \dot{\phi}Y_3 r\cos\theta\right] \qquad ; \; Y_2(o) = Y_{20}$$

$$\#6 \qquad \dot{Y}_3 = \frac{1}{r\sin\theta}\left[\frac{1}{\mu}\frac{\partial\mu}{\partial\phi} - \dot{r}Y_3\sin\theta - \dot{\theta}Y_3 r\cos\theta\right] \; ; \; Y_3(o) = Y_{30}$$

where Y_{in} are components of the normalized Y-vector, i.e.,

$$\sum_{i=1}^{3} Y_{in}^2 = \mu^2$$

$\vec{Y}$ is normalized by subroutine FORCE. The symbols r, θ, ϕ, Y_1, Y_2, Y_3 are derivatives with respect to phase path length, h_p (the independent variable), in kilometers. The symbol μ is the phase refractive index.

The simplified Appleton-Hartree expression for the phase refractive index is used. It is given by

$$\mu^2 = 1 - \frac{X}{1 - M \pm \sqrt{M^2 + Y_L^2}}$$

and the collisions are neglected.

The appropriate algebraic sign ($\pm$) in the denominator is chosen according to the indicator supplied by the user via the required input D(17). The plus (+) sign refers to ordinary rays and the minus (-) sign refers to extra-ordinary rays.

$$X = \frac{e^2 N}{\epsilon_o m(2\pi f)^2} = \frac{N}{12400.f^2} = \frac{N}{C_1}$$

N = electron density in electrons per cc

f = frequency of propagation in megacycles per second

e = charge of an electron

m = mass of an electron

ϵ_o = permittivity of free space

$$C_1 = \frac{\epsilon_o m(2\pi f)^2}{e^2} = 12400.f^2$$

$$M = \frac{\frac{1}{2} Y_T^2}{1 - X}$$

$$Y_T = \frac{f_H \sin \psi}{f}$$

$$Y_L = \frac{f_H \cos \psi}{f}$$

f_H = gyrofrequency in megacycles per sec

ψ = angle between the magnetic field and the wave normal

The problem is now reduced to one of finding N, f_H and ψ and their derivatives with respect to r, θ, ϕ, Y_1, Y_2 and Y_3. The initial coordinates of the ray-position (r_o, θ_o, ϕ_o) and the initial ray direction (Y_{10}, Y_{20}, Y_{30}) and the wave-frequency, f, should be known. Thus, for a given electron density (N) and magnetic field (f_H and ψ), one can trace rays of any frequency from any point. This is subject to the constraint that $\mu^2 \geq 0$. The local values of electron density, $N(r, \theta, \phi)$, and the magnetic field, $f_H(r, \theta, \phi)$ and $\mu(r, \theta, \phi, Y_1, Y_2, Y_3)$ are derived from the respective models.

For Hamilton's equations, one must evaluate $\partial\mu/\partial r$, $\partial\mu/\partial\theta$, $\partial\mu/\partial\phi$, $\partial\mu/\partial Y_1$, $\partial\mu/\partial Y_2$ and $\partial\mu/\partial Y_3$.

$$\frac{\partial \mu}{\partial r} = \frac{1}{2\mu M_R} \cdot \left\{ - \frac{1}{C_1} \frac{\partial N}{\partial r} + \frac{N}{C_1 M_R} \left[- \frac{\partial M}{\partial r} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial r} + \frac{Y_L^2}{f_H} \frac{\partial f_H}{\partial r} + \cos \psi \frac{f_H^2}{f^2} \frac{\partial \cos \psi}{\partial r} \right) \right] \right\}$$

$$\frac{\partial \mu}{\partial \theta} = \frac{1}{2\mu M_R} \cdot \left\{ - \frac{1}{C_1} \frac{\partial N}{\partial \theta} + \frac{N}{C_1 M_R} \left[- \frac{\partial M}{\partial \theta} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial \theta} + \frac{Y_L^2}{f_H} \frac{\partial f_H}{\partial \theta} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial \cos\psi}{\partial \theta} \right) \right] \right\}$$

$$\frac{\partial \mu}{\partial \phi} = \frac{1}{2\mu M_R} \cdot \left\{ - \frac{1}{C_1} \frac{\partial N}{\partial \phi} + \frac{N}{C_1 M_R} \left[- \frac{\partial M}{\partial \phi} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial \phi} + \frac{Y_L^2}{f_H} \frac{\partial f_H}{\partial \phi} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial \cos\psi}{\partial \phi} \right) \right] \right\}$$

$$\frac{\partial \mu}{\partial y_1} = \frac{1}{2\mu M_R^2} \left\{ \frac{N}{C_1} \left[- \frac{\partial M}{\partial y_1} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial y_1} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial \cos\psi}{\partial Y_1} \right) \right] \right\}$$

$$\frac{\partial \mu}{\partial y_2} = \frac{1}{2\mu M_R^2} \left\{ \frac{N}{C_1} \left[\frac{\partial M}{\partial y_2} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial y_2} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial \cos\psi}{\partial y_2} \right) \right] \right\}$$

$$\frac{\partial \mu}{\partial y_3} = \frac{1}{2\mu M_R^2} \left\{ \frac{N}{C_1} \left[- \frac{\partial M}{\partial y_3} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial y_3} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial \cos\psi}{\partial y_3} \right) \right] \right\}$$

$$\frac{\partial M}{\partial r} = \frac{1}{2f^2(1-x)} \left\{ 2f_H \sin^2\psi \frac{\partial f_H}{\partial r} + f_H^2 \sin\psi \frac{\partial \sin\psi}{\partial r} + \frac{\frac{f_H^2}{C_1} \sin^2\psi \frac{\partial N}{\partial r}}{1 - X} \right\}$$

$$\frac{\partial M}{\partial \theta} = \frac{1}{2f^2(1-X)} \left\{ 2f_H \sin^2\psi \frac{\partial f_H}{\partial \theta} + f_H^2 \sin\psi \frac{\partial \sin\psi}{\partial \theta} + \frac{\frac{f_H^2}{C_1} \sin^2\psi \frac{\partial N}{\partial \theta}}{1 - X} \right\}$$

$$\frac{\partial M}{\partial \phi} = \frac{1}{2f^2(1-X)} \left\{ 2f_H \sin^2\psi \frac{\partial f_H}{\partial \phi} + f_H^2 \sin\psi \frac{\partial \sin\psi}{\partial \phi} + \frac{\frac{f_H^2}{C_1} \sin^2\psi \frac{\partial N}{\partial \phi}}{1 - X} \right\}$$

$$\frac{\partial M}{\partial Y_1} = \frac{1}{(1-X)} \frac{f_H^2}{f^2} \sin\psi \frac{\partial \sin\psi}{\partial Y_1}$$

$$\frac{\partial M}{\partial Y_2} = \frac{1}{1-X} \frac{f_H^2}{f^2} \sin\psi \frac{\partial \sin\psi}{\partial Y_2}$$

$$\frac{\partial M}{\partial Y_3} = \frac{1}{1-X} \frac{f_H^2}{f^2} \sin\psi \frac{\partial \sin\psi}{\partial Y_3}$$

$$\frac{\partial \mu}{\partial f} = \frac{X}{2\mu M_R^2} \left\{ - \frac{Y_T Y_L}{1-X} + \frac{1}{R} \left(M \frac{Y_T Y_L}{1-X} - Y_T Y_L \right) \right\}$$

where

$$R = \sqrt{M^2 + Y_L^2}$$

$$M_R = 1 - M \pm R$$

The derivatives of N are calculated in DENSE (subroutine).

The derivatives of ψ and f_H are calculated in FIELD (subroutine).

Other differential equations evaluated.- Group path length, ray path length, power loss due to absorption, doppler shift, and power loss along the ray's path are the other differential equations evaluated and are discussed as follows:

(1) Group Path Length

$$\dot{G}_L = 1 + \frac{f}{\mu} \frac{\partial \mu}{\partial f} \qquad G_L(o) = 0$$

G_L is measured in km

Group delay is determined by

$$G_D = \frac{1}{c} G_L$$

where

$c = 3.0 \times 10^5$ km/sec $\equiv$ velocity of light

(2) Ray Path Length

$$\dot{S} = \frac{1}{\mu \cos \alpha} \qquad S(o) = 0$$

S is measured in km

α is the angle between the wave normal and and the ray direction

(3) Power Loss Due To Absorption

$$\dot{D} = -2 \frac{K}{\mu} D \qquad D(o) = 1.0$$

$$K = \frac{2\pi f k}{C}$$

where

D = power loss due to absorption

k = index of absorption

K = coefficient of absorption

$$k = \frac{BX}{2\mu(A^2 + B^2)} \qquad X = \frac{N e^2}{\epsilon_o m (2\pi f)^2}$$

$$A = 1 - \frac{\frac{1}{2}\left(\frac{f_H^2}{f^2}\right)\sin^2\psi(1-X)}{(1-X)^2 + Z^2} \pm \left\{\frac{1}{2}\left[U + (U^2+V^2)^{1/2}\right]\right\}^{1/2}$$

$$B = Z + \frac{\frac{1}{2} Z \left(\frac{f_H^2}{f^2}\right)\sin^2\psi}{(1-X)^2 + Z^2} \pm \frac{V}{2\left\{\frac{1}{2}\left[U + (U^2 + V^2)^{1/2}\right]\right\}^{1/2}}$$

$$U = \left[\frac{\frac{1}{2} y^2 \sin^2\psi(1-X)}{(1-X)^2 + Z^2}\right]^2 - \left[\frac{\frac{1}{2} Z y^2 \sin^2\psi}{(1-X)^2 + Z^2}\right]^2 + y^2\cos\psi$$

$$V = 2\,\frac{\frac{1}{2} y^2 \sin^2\psi(1-X)}{(1-X)^2 + Z^2} \cdot \frac{\frac{1}{2} y^2 \sin^2\psi Z}{(1-X)^2 + Z^2}$$

where

$$y = \frac{f_H}{f}$$

$$Z = \frac{\nu}{2\pi f} \qquad \nu = \text{collision frequency in collisions per sec}$$

ν is given by the collision frequency model. The collision frequency model is described in subroutine COLL.

(4) Doppler Shift

$$\Delta f = -\frac{f}{c}\int_{r_o}^{r} \mu\cos\alpha \, ds \; ; \qquad \Delta f(o) = 0$$

Δf is the Doppler-Shift in MHz

c is the velocity of light

f is the wave frequency om MHz

μ is the phase refractive index

(5) Power Loss Along the Path of the Ray

The total power loss in dB is:

$$10 \log_{10} \left\{ \frac{c^2}{4\pi f^2} \times \frac{P_{r_o}}{P_T} \times \frac{\mu_{Final}}{\mu_o} \; EXP(E_1) \times EXP(E_2) \right\}$$

$$E_1 = -\int_{s_t}^{s_L} \frac{\nabla^2 \xi}{\mu} \, ds$$

$$E_2 = -2\int_{s_o}^{s_1} \alpha_{ABS} \, ds$$

where

$$ds = \frac{dh_p}{\mu \cos \alpha}$$

s = ray path length

h_p = phase path length

$\frac{c^2}{4\pi f^2}$ = isotropic radiator aperture loss

$\frac{P_{ro}}{P_T}$ = near field loss due to refraction and inverse square law spreading

$$\text{EXP}\left[- \int_{s_t}^{s_L} \frac{\nabla^2 \xi}{\mu} \, ds \right]$$ = far field loss due to refraction and inverse square law spreading

$$\text{EXP}\left[- \int_{s_o}^{s_t} \alpha_{ABS} \, ds \right]$$ = power loss due to absorption

α_{ABS} is related to the absorption coefficient, K, of the wave by the expression

$$\alpha_{ABS} = K \cos \alpha \, .$$

Then the term

$$\text{EXP}\left[-2 \int_{s_o}^{s_t} \alpha_{ABS} \, ds \right]$$

is equivalent to D, the power loss due to absorption.

Power loss in the near field.- The power losses in the near field is calculated in MAIN. It is evaluated only once, when the ray has traveled far enough to be considered in the far field.

P_{RO}/P_T gives the power loss in the near field from s_o to s_t due to refraction and inverse square law spreading. The equation given below is for a dipole antenna.

r' and γ' are shown in the following Figure 9.

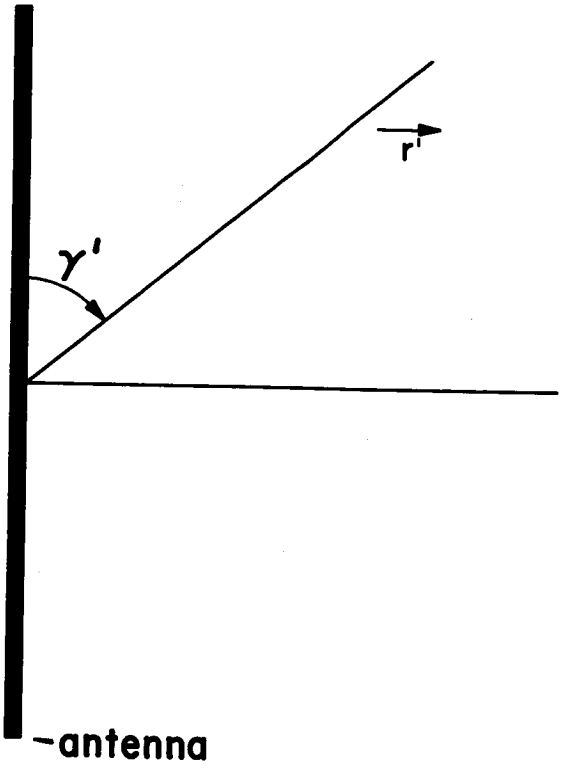


Figure 9.- Dipole antenna defined.

Let

$$C_i(P) = -\int_P^{\infty} \frac{\cos(x)}{x}\, dx$$

$$C_i(P) = \int_o^{P} \frac{\sin(x)}{x}\, dx$$

then

$$\frac{P_{RO}}{P_T} = \frac{\left[\dfrac{\cos\ (T\cos\gamma') - \cos\left(\frac{1}{2}T\right)}{\sin\gamma'}\right]^2}{2\pi(r')^2 A_1}$$

where $T = \pi\mu_o$

$$(r')^2 = r_o^2 + r^2 - 2r_o r\cos\gamma$$

$$\cos\gamma = \sin(\theta_o)\sin(\theta)\cos(\phi_o - \phi) - \cos(\theta_o)\cos(\theta)$$

$$\gamma' = \pi - \cos^{-1}\left[\frac{(r')^2 + (r_o^2) - r^2}{2r'r_o}\right]$$

$$A_1 = .5772 + \ln(T) - C_i(T)$$

$$+ \frac{1}{2}\sin(T)\left[S_i(2T) - 2S_i(T)\right]$$

$$+ \frac{1}{2}\cos(T)\left[C_i(2T) - 2C_i(T)\right]$$

$$+ \frac{1}{2}\cos(T)\left[.5772 + \ln(\tfrac{1}{2}T)\right]$$

Program Notes.- The program variable PROPT is actually

$$\frac{c^2}{4\pi f^2 \mu_o \times 10^{12}} \times \frac{P_{ro}}{P_T}$$

where

c = the velocity of light in km/sec

= 3×10^5 km/sec

Power loss in the far field.- The term

$$\frac{\mu_{Final}}{\mu_o} \int_{s_t}^{s_r} \frac{\sqrt{}^2 \xi}{\mu}\, ds$$

where ξ is the eikonal function which has the property that the surface ξ = constant is the geometrical wave-front and gives the power loss in the far field due to refraction and inverse square spreading. These are field losses calculated in POWERL routine but integrated under control of the main program.

Polarization Term.- The expression $R = E_{\bar{x}}/E_{\bar{y}}$, a complex number, is the polarization term. $E_{\bar{x}}$ and $E_{\bar{y}}$ are the components of the electric vector of the wave along axes $(\bar{x},\bar{y})$ in the wave front, $\bar{y}$ being in and $\bar{x}$ perpendicular to the plane containing the magnetic field of the Earth.

$$|R| = \text{modulus of } R = \frac{1}{Y_L}\left[\frac{\frac{1}{4}Y_T^4 + A \pm Y_T^2 A^{1/2}\cos\left(\frac{\theta}{2}\right)}{d}\right]^{1/2}$$

$$\Phi = \text{argument of } R = \tan^{-1}\left\{\frac{-\frac{1}{2}(1-X)Y_T^2 \pm A^{1/2}\left[\cos\frac{\theta}{2}(1-X) - Z\sin\frac{\theta}{2}\right]}{\frac{1}{2}Z Y_T^2 \pm A^{1/2}\left[\sin\frac{\theta}{2}(1-X) + Z\cos\frac{\theta}{2}\right]}\right\}$$

$$d = (1-X)^2 + Z^2$$

$$A = \left\{\left[\frac{1}{4}Y_T^4 + Y_L^2 d\right]^2 + \left[2 Z Y_L^2 (1-X)\right]^2\right\}^{1/2}$$

where

$$\theta = \tan^{-1}\left\{\frac{-2(1-X)Z Y_L^2}{\frac{1}{4}Y_T^4 + Y_L^2 d}\right\}$$

Evaluation of the polarization term is described under subroutine POLAR.

Dictionary of Major FORTRAN Names.- Table VIII contains a dictionary of major FORTRAN names for the MAIN program.

TABLE VIII

FORTRAN NAME	DEFINITION
PRNTO	Value of PRINT trigger
PLOTT	Value of PLOT trigger
MORDGR	Order of differences carried in integration routine
MUFLAG	Pass indicator subroutine POWERL. Equals zero for the first pass and 1 for the rest of the run
DMDR	$\frac{\partial M}{\partial r}$
DMDT	$\frac{\partial M}{\partial \theta}$
DMDP	$\frac{\partial M}{\partial \phi}$
DMDY1	$\frac{\partial M}{\partial Y_1}$
DMDY2	$\frac{\partial M}{\partial Y_2}$
DMDY3	$\frac{\partial M}{\partial Y_3}$
DMDF	$\frac{\partial M}{\partial F}$
DMUDR	$\frac{\partial \mu}{\partial r}$
DMUDT	$\frac{\partial \mu}{\partial \theta}$
DMUDP	$\frac{\partial \mu}{\partial \phi}$
DMUDY1	$\frac{\partial \mu}{\partial Y_1}$
DMUDY2	$\frac{\partial \mu}{\partial Y_2}$
DMUDY3	$\frac{\partial \mu}{\partial Y_3}$

TABLE VIII.- Concluded

FORTRAN NAME	DEFINITION
DMUDF	$\frac{\partial \mu}{\partial f}$
CAPPA	K, absorption coefficient
EPSTIN	Epstein condition
DMDSI	$\frac{\partial M}{\partial \psi}$
DMUDSI	$\frac{\partial \mu}{\partial \psi}$
YD	Array of values of differential equations
DENØM	A_1
CØSPSI	cøs γ
RP	r'
PSI	γ'
PRØPT	$\frac{P_{ro}}{P_T}$

see near field power losses

Subroutine POWERL

Description.- POWERL computes the power loss in the far field due to refraction and inverse square law spreading.

POWERL evaluates

$$\dot{P}_F = \frac{\nabla^2 \zeta}{\mu^2 \cos\alpha}$$

where ζ is the eikonal function which has the property that the surface ζ = constant is the geometrical wave front.

Derivation of ∇_ζ^2

$$\nabla\zeta = n\frac{d\bar{r}'}{ds} = \mu\left(\frac{\partial r'}{\partial s}\ \hat{r}'\right)$$

$$= \mu\left(\frac{\partial r'}{\partial r}\dot{r} + \frac{\partial r'}{\partial\theta}\dot{\theta} + \frac{\partial r'}{\partial\phi}\dot{\phi}\right)\frac{\partial h_p}{\partial s}\hat{r}' = \mu\,\dot{r}'\,\hat{r}'$$

where

$$\dot{r}' = \frac{1}{\sqrt{\mu^2 + \left(\frac{\partial\mu}{\partial\psi}\right)^2}}\left\{\frac{\partial r'}{\partial r}\left(y_1 - \mu\frac{\partial\mu}{\partial y_1}\right) + \frac{\partial r'}{\partial\theta}\ \frac{1}{r}\left(y_2 - \mu\frac{\partial\mu}{\partial y_2}\right)\right.$$

$$\left. + \frac{\partial r'}{\partial\phi}\ \frac{1}{r\sin\theta}\left(y_3 - \mu\frac{\partial\mu}{\partial y_3}\right)\right\}$$

$$\nabla^2\zeta = \mathrm{div}\left(\mu\frac{\partial\bar{r}'}{\partial s}\right) = \frac{1}{(r')^2}\ \frac{\partial}{\partial r'}\ (\mu(r')^2\dot{r}')$$

where

$$\frac{1}{(r')^2}\ \frac{\partial}{\partial r'}\ (\mu(r')^2\dot{r}') = \left(\frac{2\mu}{r'} + \frac{\partial\mu}{\partial r'}\right)\dot{r}' - \frac{\mu\dot{r}'\left(\mu\frac{\partial\mu}{\partial r'} + \frac{\partial\mu}{\partial\psi}\ \frac{\partial^2\mu}{\partial r'\partial\psi}\right)}{\left(\mu^2 + \left(\frac{\partial\mu}{\partial\psi}\right)^2\right)}$$

$$- \frac{\mu}{\left(\mu^2 + \left(\frac{\partial\mu}{\partial\psi}\right)^2\right)^{1/2}}\left\{\frac{\partial r'}{\partial r}\left(\frac{\partial\mu}{\partial r'}\ \frac{\partial\mu}{\partial y_1} + \mu\frac{\partial^2\mu}{\partial r'\partial y_1}\right)\right.$$

$$+ \frac{1}{r}\ \frac{\partial r'}{\partial\theta}\left[\frac{1}{r}\ \frac{\partial r}{\partial r'}\left(y_2 - \mu\frac{\partial\mu}{\partial y_2}\right) + \left(\frac{\partial\mu}{\partial r'}\ \frac{\partial\mu}{\partial y_2} + \mu\frac{\partial^2\mu}{\partial r'\partial y_2}\right)\right]$$

$$+ \frac{1}{r\sin\theta}\ \frac{\partial r'}{\partial\phi}\left[\left(\frac{1}{r}\ \frac{\partial r}{\partial r'} + \frac{\cos\theta}{\sin\theta}\ \frac{\partial\theta}{\partial r'}\right)\left(y_3 - \mu\frac{\partial\mu}{\partial y_3}\right)\right.$$

$$\left.\left. + \frac{\partial\mu}{\partial r'}\ \frac{\partial\mu}{\partial y_3} + \mu\frac{\partial^2\mu}{\partial r'\partial y_3}\right]\right\}$$

The derivatives of r' with respect to r, θ, ϕ are:

$$\frac{\partial r'}{\partial r} = \frac{1}{r'}\left[r - r_o\left(\sin\theta \sin\theta_o \cos(\phi-\phi_o) + \cos\theta \cos\theta_o \right)\right]$$

$$\frac{\partial r'}{\partial \theta} = \frac{rr_o}{r'}\left[\cos\theta_o \sin\theta - \sin\theta_o \cos\theta \cos(\phi-\phi_o)\right]$$

$$\frac{\partial r'}{\partial \phi} = \frac{rr_o}{r'} \sin\theta \sin\theta_o \sin(\phi-\phi_o)$$

To find the derivatives of r, θ, ϕ with respect to r', we differentiate the equations defining r', θ', ϕ' with respect to r'. In general, we have

$$\frac{1}{2}\frac{\partial}{\partial r'}(r')^2 = r\frac{\partial r}{\partial r'} - r_o\frac{\partial r}{\partial r'}\left(\sin\theta \sin\theta_o \cos(\phi-\phi_o) \right.$$

$$\left. + \cos\theta \cos\theta_o \right) - rr_o\left(\cos\theta \sin\theta_o \cos(\phi-\phi_o)\frac{\partial \theta}{\partial r'} \right.$$

$$\left. - \sin\theta \cos\theta_o \frac{\partial \theta}{\partial r'} - \sin\theta \sin\theta_o \sin(\phi-\phi_o)\frac{\partial \phi}{\partial r'} \right)$$

$$\frac{\partial}{\partial r'}(r'\cos\theta') = \cos\theta \frac{\partial r}{\partial r'} - r\sin\theta \frac{\partial \theta}{\partial r'}$$

$$\frac{\partial}{\partial r'}(r'\sin\theta'\cos\phi') = \sin\theta\cos\phi \frac{\partial r}{\partial r'} + r\cos\theta\cos\phi \frac{\partial \theta}{\partial r'}$$

$$- r\sin\theta\sin\phi \frac{\partial \phi}{\partial r'}$$

We then solve these three simultaneous equations for

$$\frac{\partial r}{\partial r'}, \quad \frac{\partial \theta}{\partial r'}, \text{ and } \frac{\partial \phi}{\partial r'}$$

Now we must find the derivatives of μ with respect to the r, θ, ϕ system. The first derivatives of μ are given in MAIN PROGRAM. It remains to find the second derivatives.

$$\frac{\partial^2\mu}{\partial\psi\partial r} = -\frac{1}{\mu}\frac{\partial\mu}{\partial\psi}\frac{\partial\mu}{\partial r} - \frac{1}{A}\frac{\partial\mu}{\partial r}\frac{\partial A}{\partial\psi} + \frac{N}{2\mu C_1 A^2}\left[-\frac{\partial^2 M}{\partial\psi\,\partial r}\right.$$

$$-\frac{1}{B}\frac{\partial B}{\partial\psi}\frac{\partial B}{\partial r} + \frac{1}{B}\left(\frac{\partial M}{\partial r}\frac{\partial M}{\partial\psi} + M\frac{\partial^2 M}{\partial\psi\partial r}\right.$$

$$-2\frac{f_H}{f^2}\cos\psi\sin\psi\frac{\partial f_H}{\partial r} - \frac{f_H^2}{f^2}\sin\psi\frac{\partial\cos\psi}{\partial r}$$

$$\left.\left.+\frac{f_H^2}{f^2}\frac{\cos^2\psi}{\sin\psi}\frac{\partial\cos\psi}{\partial r}\right)\right] - \frac{N}{2\mu C_1 A^3}\frac{\partial A}{\partial r}\frac{\partial A}{\partial\psi}$$

$$\frac{\partial^2\mu}{\partial\psi\partial\theta} = -\frac{1}{\mu}\frac{\partial\mu}{\partial\psi}\frac{\partial\mu}{\partial\theta} - \frac{1}{A}\frac{\partial\mu}{\partial\theta}\frac{\partial A}{\partial\psi} + \frac{N}{2\mu C_1 A^2}\left[-\frac{\partial^2 M}{\partial\psi\,\partial\theta}\right.$$

$$-\frac{1}{B}\frac{\partial B}{\partial\theta}\frac{\partial B}{\partial\psi} + \frac{1}{B}\left(\frac{\partial M}{\partial\psi}\frac{\partial M}{\partial\theta} + M\frac{\partial^2 M}{\partial\psi\partial\theta}\right.$$

$$-2\frac{f_H}{f^2}\cos\psi\sin\psi\frac{\partial f_H}{\partial\theta} - \frac{f_H^2}{f^2}\sin\psi\frac{\partial\cos\psi}{\partial\theta}$$

$$\left.\left.+\frac{f_H^2}{f^2}\frac{\cos^2\psi}{\sin\psi}\frac{\partial\cos\psi}{\partial\theta}\right)\right] - \frac{N}{2\mu C_1 A^3}\frac{\partial A}{\partial\theta}\frac{\partial A}{\partial\psi}$$

$$\frac{\partial^2\mu}{\partial\psi\partial\phi} = -\frac{1}{\mu}\frac{\partial\mu}{\partial\psi}\frac{\partial\mu}{\partial\phi} - \frac{1}{A}\frac{\partial\mu}{\partial\phi}\frac{\partial A}{\partial\psi} + \frac{N}{2\mu C_1 A^2}\left[-\frac{\partial^2 M}{\partial\psi\partial\phi}\right.$$

$$-\frac{1}{B}\frac{\partial B}{\partial\phi}\frac{\partial B}{\partial\psi} + \frac{1}{B}\left(\frac{\partial M}{\partial\psi}\frac{\partial M}{\partial\phi} + M\frac{\partial^2 M}{\partial\psi\partial\phi}\right.$$

$$-2\frac{f_H}{f^2}\cos\psi\sin\psi\frac{\partial f_H}{\partial\phi} - \frac{f_H^2}{f^2}\sin\psi\frac{\partial\cos\psi}{\partial\phi}$$

$$\left.\left.+\frac{f_H^2}{f^2}\frac{\cos^2\psi}{\sin\psi}\frac{\partial\cos\psi}{\partial\phi}\right)\right] - \frac{N}{2\mu C_1 A^3}\frac{\partial A}{\partial\phi}\frac{\partial A}{\partial\psi}$$

$$\frac{\partial^2\mu}{\partial y_1\partial r} = \frac{1}{2\mu}\left[\frac{1}{A^2 C_1}\left(\frac{\partial A}{\partial y_1}\frac{\partial N}{\partial r} - \frac{2N}{A}\frac{\partial A}{\partial r}\right) + \frac{N}{A^2 C_1}\frac{\partial^2 A}{\partial y_1\partial r}\right.$$

$$\left.-2\frac{\partial\mu}{\partial r}\frac{\partial\mu}{\partial y_1}\right]$$

$$\frac{\partial^2\mu}{\partial y_2\partial\theta} = \frac{1}{2\mu}\left[\frac{1}{A^2 C_1}\frac{\partial A}{\partial y_2}\left(\frac{\partial N}{\partial\theta} - \frac{2N}{A}\frac{\partial A}{\partial\theta}\right) + \frac{N}{A^2 C_1}\frac{\partial^2 A}{\partial y_2\partial\theta}\right.$$

$$\left.-2\frac{\partial\mu}{\partial\theta}\frac{\partial\mu}{\partial y_2}\right]$$

$$\frac{\partial^2\mu}{\partial y_3\partial\phi} = \frac{1}{2\mu}\left[\frac{1}{A^2 C_1}\frac{\partial A}{\partial y_3}\left(\frac{\partial N}{\partial\phi} - \frac{2N}{A}\frac{\partial A}{\partial\phi}\right) + \frac{N}{A^2 C_1}\frac{\partial^2 A}{\partial y_3\partial\phi}\right.$$

$$\left.-2\frac{\partial\mu}{\partial\phi}\frac{\partial\mu}{\partial y_3}\right]$$

where $$A = 1 - M \pm \sqrt{M^2 + \frac{f_H^2}{f^2} \cos^2\psi}$$

$$B = \sqrt{M^2 + \frac{f_H^2}{f^2} \cos^2\psi}$$

$$M = \frac{1}{2} \frac{f_H^2}{f^2} \frac{\sin^2\psi}{C}$$

and $$C = 1 - \frac{N}{C_1}$$

$$\frac{\partial^2 M}{\partial\psi\partial r} = \frac{1}{2f^2} \frac{1}{\left(1 - \frac{N}{C_1}\right)} \left\{ 4 f_H \sin\psi \cos\psi \frac{\partial f_H}{\partial r} + 2 f_H^2 \cos\psi \frac{\partial \sin\psi}{\partial r} \right.$$

$$\left. + 2 f_H^2 \sin\psi \frac{\partial \cos\psi}{\partial r} + \frac{2 f_H^2 \sin\psi \cos\psi \frac{\partial N}{\partial r}}{\left(C_1 \left[1 - \frac{N}{C_1} \right] \right)} \right\}$$

$$\frac{\partial^2 M}{\partial\psi\partial\theta} = \frac{1}{2f^2} \frac{1}{\left(1 - \frac{N}{C_1}\right)} \left\{ 4 f_H \sin\psi \cos\psi \frac{\partial f_H}{\partial\theta} + 2 f_H^2 \cos\psi \frac{\partial \sin\psi}{\partial\theta} \right.$$

$$\left. + 2 f_H^2 \sin\psi \frac{\partial \cos\psi}{\partial\theta} + \frac{2 f_H^2 \sin\psi \cos\psi \frac{\partial N}{\partial\theta}}{\left(C_1 \left[1 - \frac{N}{C_1} \right] \right)} \right\}$$

$$\frac{\partial^2 M}{\partial\psi\partial\phi} = \frac{1}{2f^2}\frac{1}{\left(1-\frac{N}{C_1}\right)}\left\{4f_H \sin\psi\cos\psi\frac{\partial f_H}{\partial\phi} + 2f_H^2\cos\psi\frac{\partial\sin\psi}{\partial\phi}\right.$$

$$\left. + 2f_H^2\sin\psi\frac{\partial\cos\psi}{\partial\phi} + \frac{2f_H^2\sin\psi\cos\psi\frac{\partial N}{\partial\phi}}{\left(C_1\left[1-\frac{N}{C_1}\right]\right)}\right\}$$

$$\frac{\partial^2 M}{\partial r\partial y_1} = \frac{1}{f^2 C}\left\{2f_H\sin\psi\frac{\partial\sin\psi}{\partial y_1}\frac{\partial f_H}{\partial r} + f_H^2\frac{\partial\sin\psi}{\partial r}\frac{\partial\sin\psi}{\partial y_1}\right.$$

$$\left. + f_H^2\sin\psi\frac{\partial^2\sin\psi}{\partial r\partial y_1} + \frac{f_H^2}{CC_1}\sin\psi\frac{\partial\sin\psi}{\partial y_1}\frac{\partial N}{\partial r}\right\}$$

$$\frac{\partial^2 M}{\partial\theta\partial y_2} = \frac{1}{f^2 C}\left\{2f_H\sin\psi\frac{\partial\sin\psi}{\partial y_2}\frac{\partial f_H}{\partial\theta} + f_H^2\frac{\partial\sin\psi}{\partial y_2}\frac{\partial\sin\psi}{\partial\theta}\right.$$

$$\left. + f_H^2\sin\psi\frac{\partial^2\sin\psi}{\partial\theta\partial y_2} + \frac{f_H^2}{CC_1}\sin\psi\frac{\partial\sin\psi}{\partial y_2}\frac{\partial N}{\partial\theta}\right\}$$

$$\frac{\partial^2 M}{\partial\phi\partial y_3} = \frac{1}{f^2 C}\left\{2f_H\sin\psi\frac{\partial\sin\psi}{\partial y_3}\frac{\partial f_H}{\partial\phi} + f_H^2\frac{\partial\sin\psi}{\partial\phi}\frac{\partial\sin\psi}{\partial y_3}\right.$$

$$\left. + f_H^2\sin\psi\frac{\partial^2\sin\psi}{\partial\phi\partial y_3} + \frac{f_H^2}{CC_1}\sin\psi\frac{\partial\sin\psi}{\partial y_3}\frac{\partial N}{\partial\phi}\right\}$$

$$\frac{\partial^2 A}{\partial r \partial y_1} = -\frac{\partial^2 M}{\partial r \partial y_1} \mp \frac{1}{B^3}\left(M \frac{\partial M}{\partial r} + \frac{f_H}{f^2}\cos\psi \left[\cos\psi \frac{\partial f_H}{\partial r} + f_H \frac{\partial \cos\psi}{\partial r} \right] \right) \left(M \frac{\partial M}{\partial y_1} + \frac{f_H^2}{f^2}\cos\psi \frac{\partial \cos\psi}{\partial y_1} \right)$$

$$\pm \frac{1}{B}\left\{ \frac{\partial M}{\partial r} \frac{\partial M}{\partial y_1} + M \frac{\partial^2 M}{\partial r \partial y_1} + \frac{2 f_H}{f^2}\cos\psi \frac{\partial \cos\psi}{\partial y_1} \frac{\partial f_H}{\partial r} + \frac{f_H^2}{f^2}\left(\frac{\partial \cos\psi}{\partial r} \frac{\partial \cos\psi}{\partial y_1} + \cos\psi \frac{\partial^2 \cos\psi}{\partial r \partial y_1} \right) \right\}$$

$$\frac{\partial^2 A}{\partial \theta \partial y_2} = -\frac{\partial^2 M}{\partial \theta \partial y_2} \mp \frac{1}{B^3}\left(M \frac{\partial M}{\partial \theta} + \frac{f_H}{f^2}\cos\psi \left[\cos\psi \frac{\partial f_H}{\partial \theta} + f_H \frac{\partial \cos\psi}{\partial \theta} \right] \right) \left(M \frac{\partial M}{\partial y_2} + \frac{f_H^2}{f^2}\cos\psi \frac{\partial \cos\psi}{\partial y_2} \right)$$

$$\pm \frac{1}{B}\left\{ \frac{\partial M}{\partial \theta} \frac{\partial M}{\partial y_2} + M \frac{\partial^2 M}{\partial \theta \partial y_2} + \frac{2 f_H}{f^2}\cos\psi \frac{\partial \cos\psi}{\partial y_2} \frac{\partial f_H}{\partial \theta} + \frac{f_H^2}{f^2}\left(\frac{\partial \cos\psi}{\partial \theta} \frac{\partial \cos\psi}{\partial y_2} + \cos\psi \frac{\partial^2 \cos\psi}{\partial \theta \partial y_2} \right) \right\}$$

$$\frac{\partial^2 A}{\partial\phi\partial y_3} = -\frac{\partial^2 M}{\partial\phi\partial y_3} \mp \frac{1}{B^3}\left(M\frac{\partial M}{\partial\phi} + \frac{f_H}{f^2}\cos\psi\left[\cos\psi\frac{\partial f_H}{\partial\phi}\right.\right.$$

$$\left.\left. + f_H\frac{\partial\cos\psi}{\partial\phi}\right]\right)\left(M\frac{\partial M}{\partial y_3} + \frac{f_H^2}{f^2}\cos\psi\frac{\partial\cos\psi}{\partial y_3}\right)$$

$$\mp\frac{1}{B}\left\{\frac{\partial M}{\partial\phi}\frac{\partial M}{\partial y_3} + M\frac{\partial^2 M}{\partial\phi\partial y_3} + \frac{2f_H}{f^2}\cos\psi\frac{\partial\cos\psi}{\partial y_3}\right.$$

$$\left. + \frac{f_H^2}{f^2}\left(\frac{\partial\cos\psi}{\partial\phi}\frac{\partial\cos\psi}{\partial y_3} + \cos\psi\frac{\partial^2\cos\psi}{\partial\phi\partial y_3}\right)\right\}$$

The derivatives of f_H, cos ψ, and sin ψ depend on the particular magnetic field model used.

The power loss as computed above (and ray-tracing in general) is valid only when the following conditions are fulfilled:

$$\frac{1}{k\mu}\frac{\nabla\mu}{\mu} << 1 \quad \text{where } k = \frac{2\pi}{\lambda}$$

and

$$\frac{1}{k\mu}\frac{\nabla PL}{PL} << 1$$

These conditions are violated in rapidly varying media or when a caustic is encountered. Figure 10 is a flow chart of the subroutine POWERL.

Dictionary of major FORTRAN names.-Table IX contains a dictionary of major FORTRAN names, subroutine POWERL.

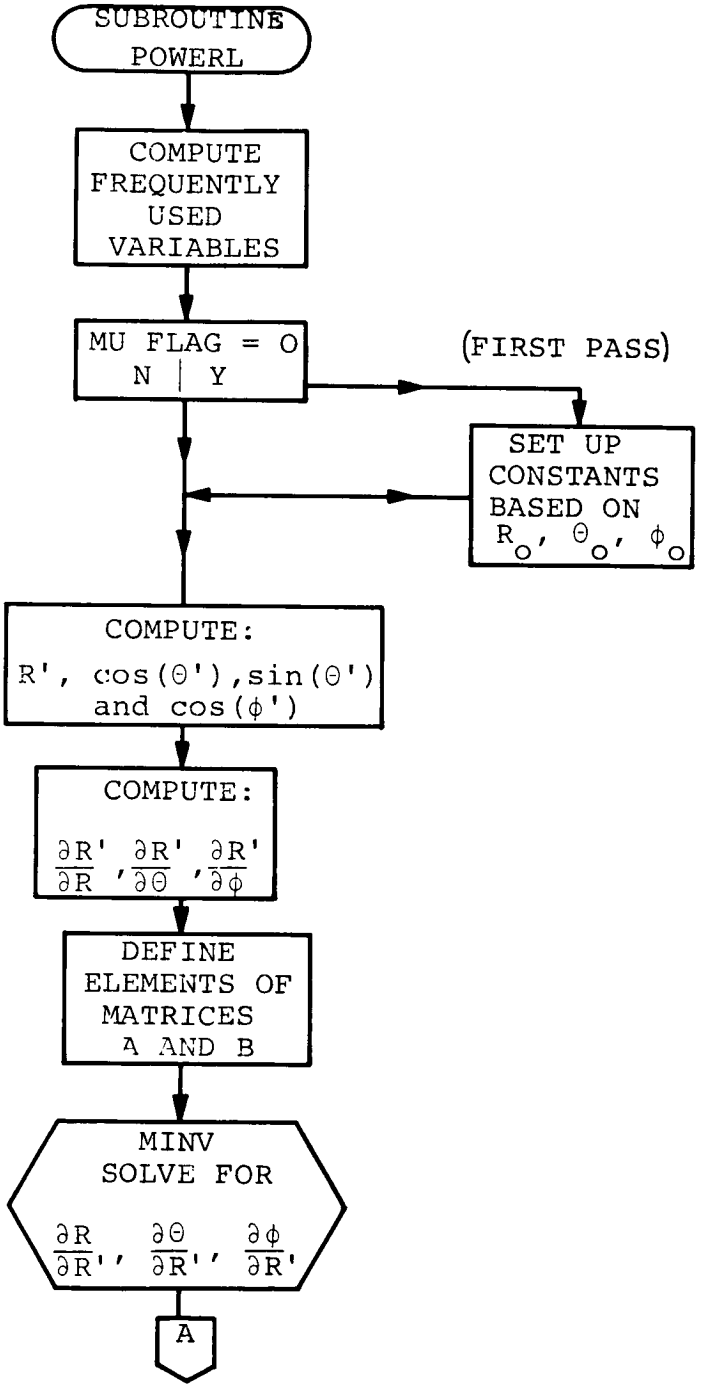


Figure 10A. - Flow Chart of Subroutine POWERL

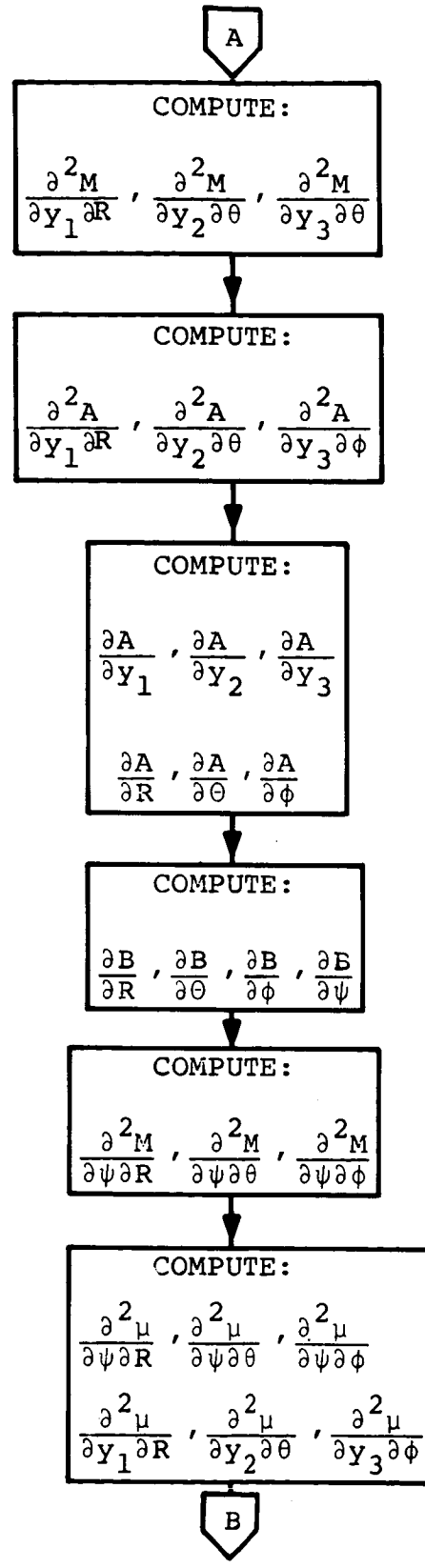


Figure 10B. - Flow Chart of Subroutine POWERL

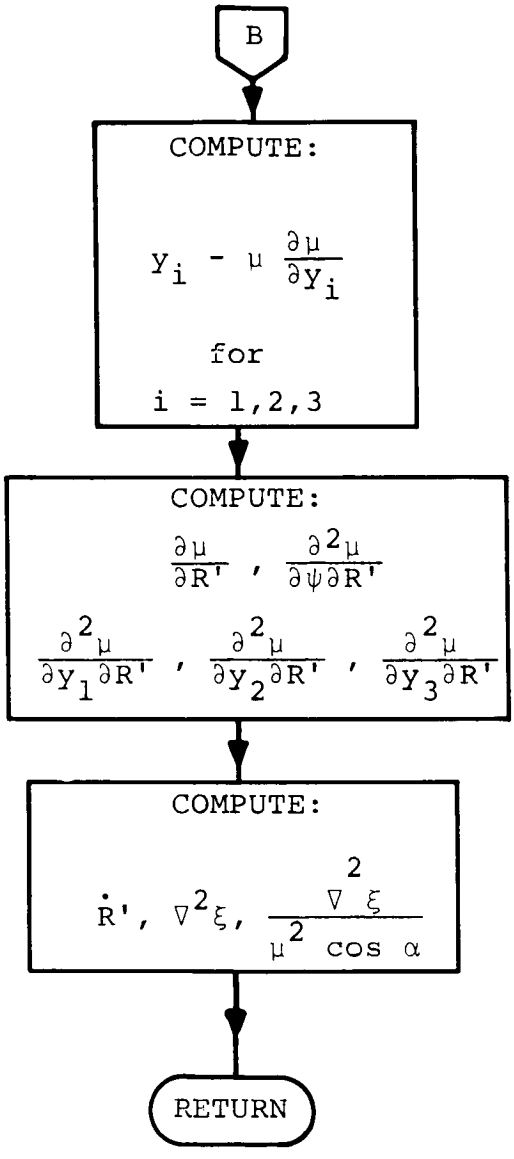


Figure 10C. - Flow Chart of Subroutine POWERL

TABLE IX

FORTRAN Name	Definition
DRPDR	$\frac{\partial r'}{\partial r}$
DRPDT	$\frac{\partial r'}{\partial \theta}$
DRPDP	$\frac{\partial r'}{\partial \phi}$
DSITP	$\cos(\phi')$
COTP	$\cos(\theta')$
COPP	$\sin(\theta)$
DRDRP	$\frac{\partial r}{\partial r'}$
DTDRP	$\frac{\partial \theta}{\partial r'}$
DPDRP	$\frac{\partial \phi}{\partial r'}$
D2MY1R	$\frac{\partial^2 M}{\partial y_1 \partial r}$
D2MY2T	$\frac{\partial^2 M}{\partial y_2 \partial \theta}$
D2MY3P	$\frac{\partial^2 M}{\partial y_3 \partial \phi}$

TABLE IX.- Continued

FORTRAN Name	Definition
D2AY1R	$\frac{\partial^2 A}{\partial y_1 \partial r}$
D2AY2T	$\frac{\partial^2 A}{\partial y_2 \partial \theta}$
D2AY3P	$\frac{\partial^2 A}{\partial y_3 \partial \phi}$
DADY1	$\frac{\partial A}{\partial y_1}$
DADY2	$\frac{\partial A}{\partial y_2}$
DADY3	$\frac{\partial A}{\partial y_3}$
DADR	$\frac{\partial A}{\partial r}$
DADT	$\frac{\partial A}{\partial \theta}$
DADP	$\frac{\partial A}{\partial \phi}$
DBDR	$\frac{\partial B}{\partial r}$
DBDT	$\frac{\partial B}{\partial \theta}$
DBDP	$\frac{\partial B}{\partial \phi}$

TABLE IX.- Continued

FORTRAN Name	Definition
DBDSI	$\frac{\partial B}{\partial \psi}$
D2MDSR	$\frac{\partial^2 M}{\partial \psi \partial R}$
D2MDST	$\frac{\partial^2 M}{\partial \psi \partial \theta}$
D2MDSP	$\frac{\partial^2 M}{\partial \psi \partial \phi}$
D2UDSR	$\frac{\partial^2 \mu}{\partial \psi \partial r}$
D2UDST	$\frac{\partial^2 \mu}{\partial \psi \, \partial \theta}$
D2UDSP	$\frac{\partial^2 \mu}{\partial \psi \partial \phi}$
D2UY1R	$\frac{\partial^2 \mu}{\partial Y_1 \partial r}$
D2UY2T	$\frac{\partial^2 \mu}{\partial Y_2 \partial \theta}$
D2UY3P	$\frac{\partial^2 \mu}{\partial Y_3 \partial \phi}$
YPEMDU	$Y_1 - \mu \frac{\partial \mu}{\partial Y_1}$

TABLE IX.- Concluded

FORTRAN Name	Definition
YP2MDU	$Y_2 - \mu \frac{\partial \mu}{\partial Y_2}$
YP3MDU	$Y_3 - \mu \frac{\partial \mu}{\partial Y_3}$
DMUDRP	$\frac{\partial \mu}{\partial r'}$
DUDSRP	$\frac{\partial^2 \mu}{\partial \psi \partial r'}$
DUY1RP	$\frac{\partial^2 \mu}{\partial Y_1 \partial r'}$
DUY2RP	$\frac{\partial^2 \mu}{\partial Y_2 \partial r'}$
DUY3RP	$\frac{\partial^2 \mu}{\partial Y_3 \partial r'}$
RDØTP	$\dot{r}'$
DEL2S	$\nabla^2 \zeta$
YD(11)	$\dot{P}_F = \frac{\nabla^2 \zeta}{\mu^2 \cos\alpha}$

Subroutine INPUT

Description.- The purpose of the INPUT routine is to bring into core the user's data and then convert it into a useable format. (See flow chart in Figure 11.) Most of the initialization

is performed here. Since all the information referring to the input section is already presented in Section II, it is sufficient to present only the flow chart and the listing of the subroutine.

Dictionary of major FORTRAN names.- Table X contains a dictionary of major FORTRAN names.

TABLE X

FORTRAN Name	Data Type	Definition
V	Numeric array	Coefficients used to calculate $N_x(r)$
W	Numeric array	Coefficients used to calculate $N_x(r)$
D	Numeric array	Dummy input array
XNAME1	Name list	Description in Section II
XNAME3	Name list	Description in Section II
XNAME5	Name list	Description in Section II
H		Scale size of electron density distribution
HPRIME		Point of maximum electron density gradient
ZX		$\frac{r}{r}(r - r)$
ENF		N_F Electron density in F region
ENXR		$N_x(r)$
ENX		N_x Electron density in exosphere
EN		Total electron density, $N_x + N_F = N$

TABLE X.- Concluded

FORTRAN Name	Data Type	Definitions
PKDELN		ΔN_o = PKFRAC * N(PKFRAC is in percent)
PLT		Array used to store plotting title information
YO	Array	Contains value of differential equations evaluated
NUAR		Number of differential equations evaluated

Subroutine Output

Description.- Final calculations are made in OUTPUT prior to printing results.

(1) DOPPLER SHIFT - DSHIFT

$$\Delta f = -(2.424067E\text{-}4).f\int_o^{h_p} \frac{1}{\mu}\,\frac{\partial \mu}{\partial \phi}\, dh_p$$

(2) VALIDITY CRITERION - VALCRIT

$$V_c = K\left[\left(\frac{\partial \mu}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial \mu}{\partial \theta}\right)^2 + \frac{1}{(r\cos\theta)^2}\left(\frac{\partial \mu}{\partial \phi}\right)^2\right]^{1/2}$$

where

$$K = \frac{1}{K_1 f \mu^2 .10^6}$$

$$K_1 = \frac{2\pi}{c} = 2.0943933E\text{-}5$$

c = speed of light in km

f = signal frequency in megacycles/sec.

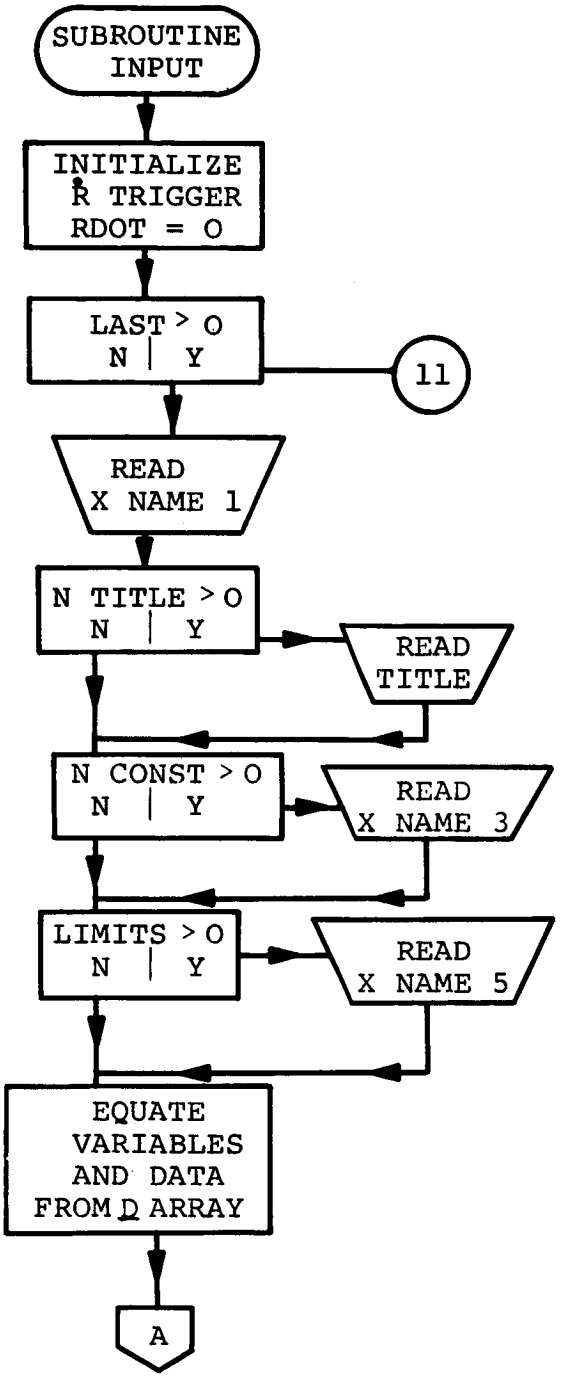


Figure 11A. - Flow Chart of Subroutine INPUT

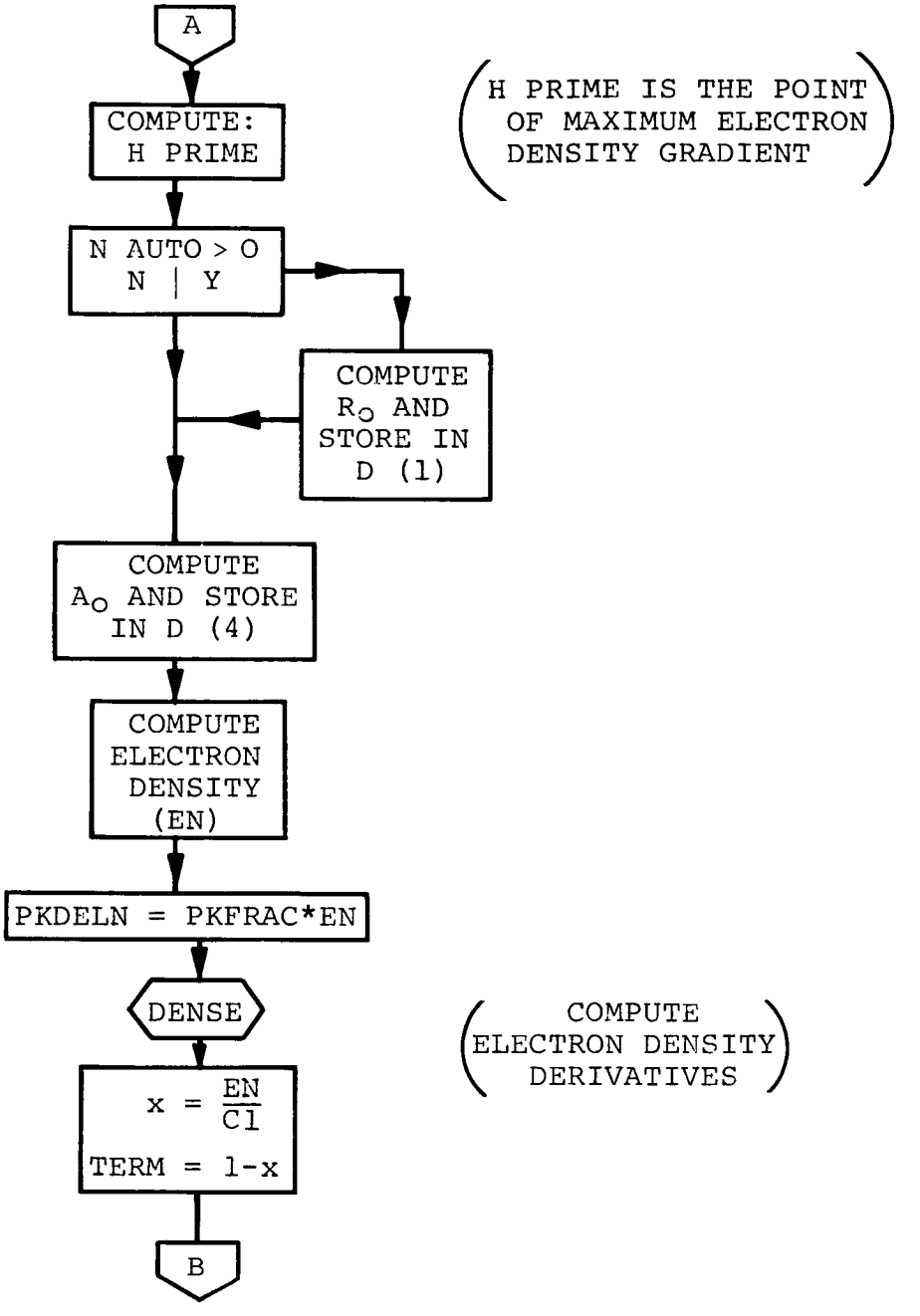


Figure 11B. - Flow Chart of Subroutine INPUT

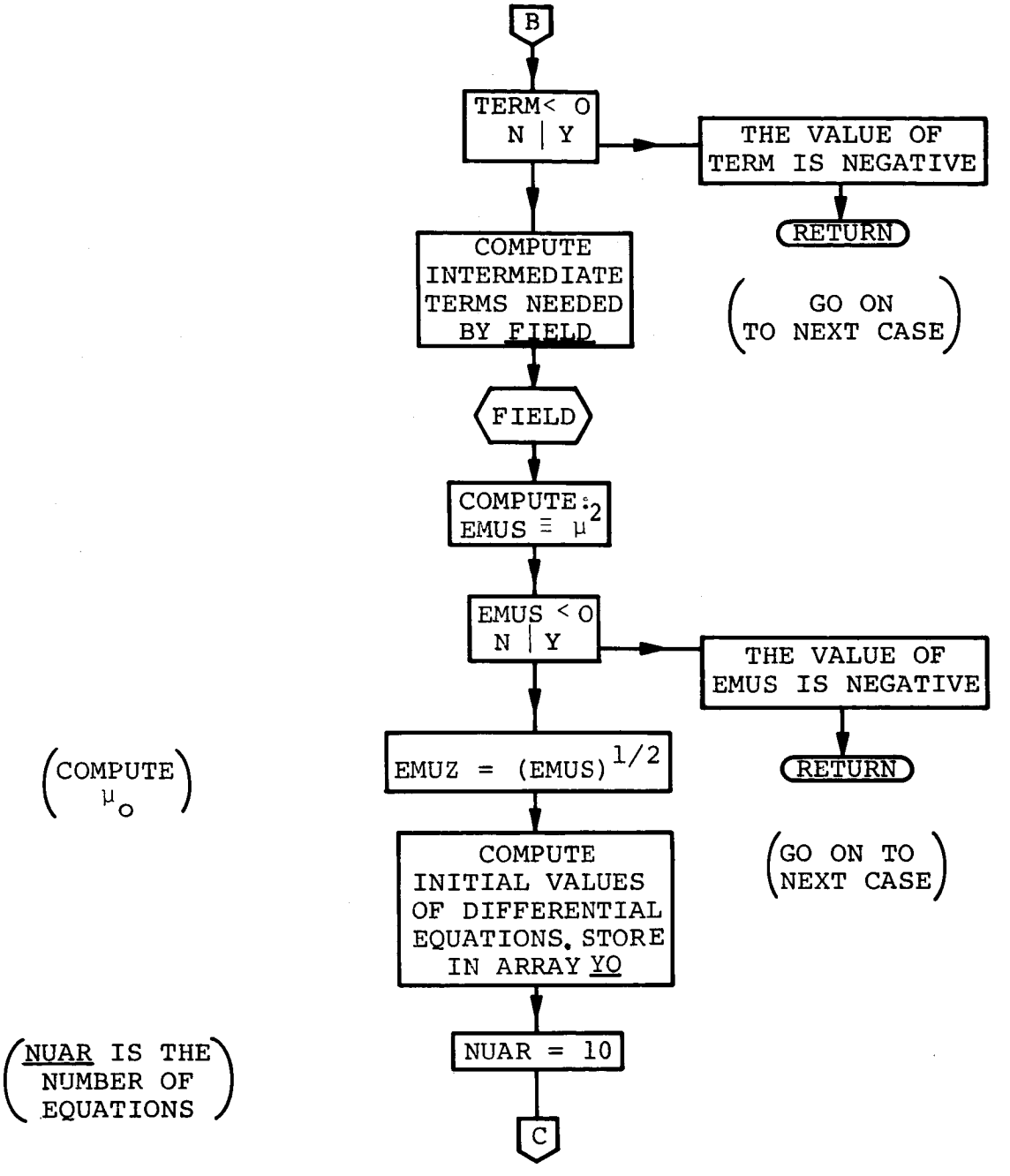


Figure 11C. - Flow Chart of Subroutine INPUT

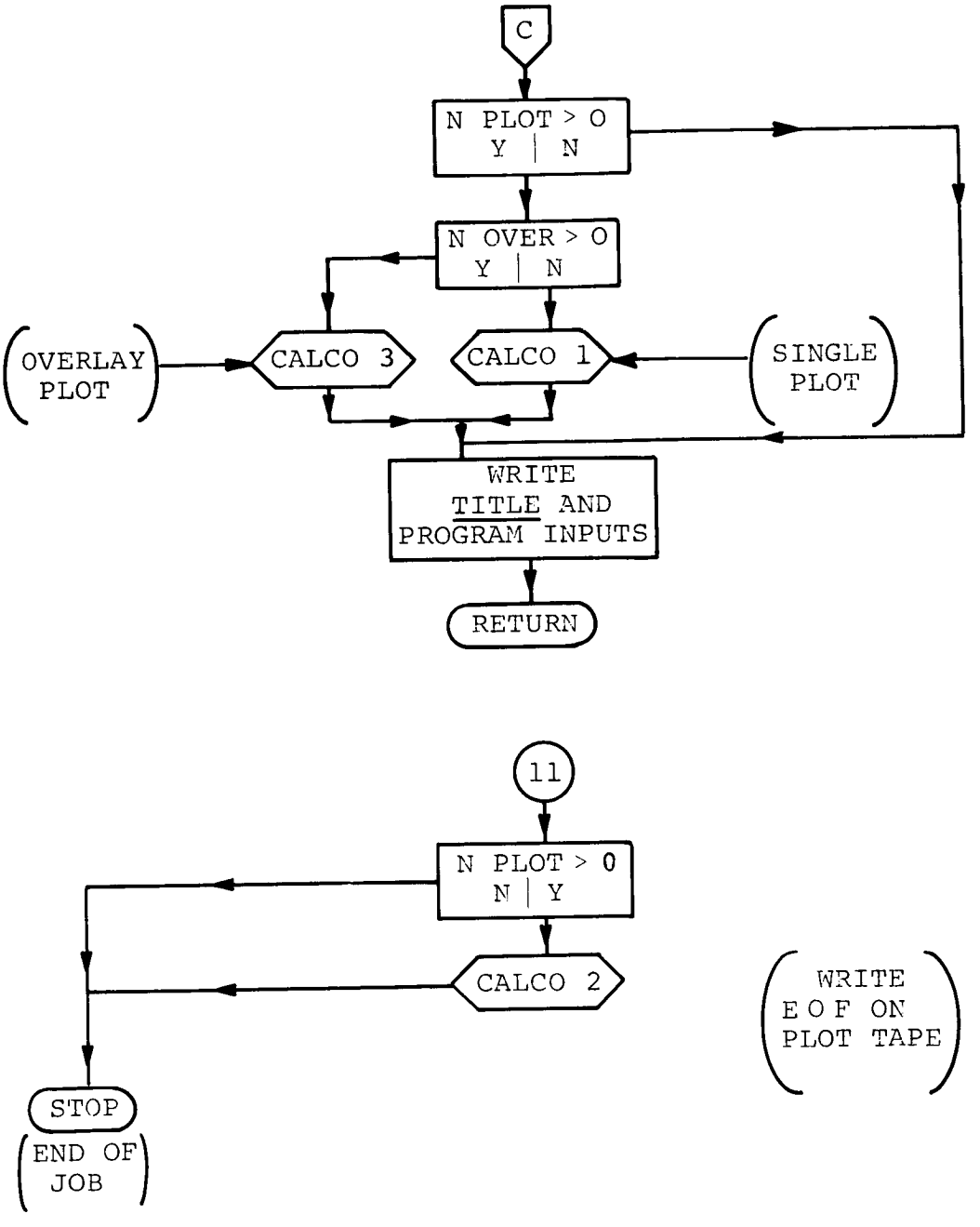


Figure 11D. - Flow Chart of Subroutine INPUT

In the flow chart convention:

$$DM\mu DR = \frac{\partial \mu}{\partial r} \qquad Y\emptyset(1) = r$$

$$DMUDT = \frac{\partial \mu}{\partial \theta} \qquad RCT = r\cos\theta$$

$$DMUDP = \frac{\partial \mu}{\partial \phi} \qquad EMUS = \mu^2$$

(3) TOTAL POWER LOSS IN DB - PL -

$$P_L = 10 \log_{10} \left(\mu \; PR\emptyset PT \; EXP \left[- \int_o^{h_p} \frac{\nabla^2 \zeta}{\mu^2 \cos\alpha} \, dh_p \right] \right)$$

where

$$YD(11) = \dot{P}_F = \frac{\nabla^2 \zeta}{\mu^2 \cos\alpha}$$

$$Y\emptyset(11) = \int_o^{h_p} \dot{P}_F \, dh_p$$

$$PR\emptyset PT = \frac{P_{ro}}{P_T} \times \frac{c^2}{4\pi f^2 \mu_o \times 10^{12}}$$

(4) GROUP DELAY IN MILLISECONDS - GRODEL

$$GR\emptyset DEL = \frac{1}{c} \int_o^{h_p} \left(1 + \frac{f \times 1.0E6}{\mu} \frac{\partial \mu}{\partial f} \right) dh_p$$

where f is the frequency in MHz and $dh_p = \mu \cos \alpha \, ds$.

In the flow chart convention:

$$YD(7) = \dot{G}_L = 1 + \frac{f \bullet 1.0E6}{\mu} \frac{\partial \mu}{\partial f}$$

$$Y\emptyset(7) = \int_o^{h_p} \dot{G}_L \, dh_p = G_L$$

$$GR\emptyset DEL = \frac{G_L}{c}$$

where

G_L = group path length in km

c = speed of light in km/sec

$= 3 \times 10^2$

Also, see the flow chart, Figure 12.

Dictionary of major FORTRAN names.- Table XI contains a dictionary of major FORTRAN names, subroutine OUTPUT.

TABLE XI

FORTRAN Name	Data Type	Definition
THETA		Colatitude of wave front in degrees
PHI		Longitude of wave front in degrees
YØSQR		$[Y\emptyset(4)]^2 + [Y\emptyset(5)]^2 + [Y\emptyset(6)]^2$
DSHIFT		Doppler shift, Δf.
C2		4.24737E-6/F, used to calculate dispersion

TABLE XI.- Concluded

FORTRAN Name	Data Type	Definition
VALCRIT		Validity criterion for μ^2
PL		Total power loss in db, exclusive of absorption
GRØDEL		Group delay in milliseconds
XX	Array	Array used to store geocentric radius for plot of total ray path
YY	Array	Array used to store colatitude for plot of total ray path, theta in degrees
LL		Number of points in the XX and YY arrays 500 points maximum
JFLAG		Program indicator, used to indicate reason OUTPUT was called
JUMP		Program indicator, used to indicate that an end of case condition exists
N		Program indicator, used as a line counter

Subroutine COLL

Description.- The collision frequency model has the following functional form:

$$\nu = 10^{\nu'}$$

where ν' is computed as shown below. (Also, see flow chart, Figure 13.) The collision frequency profile as a function of

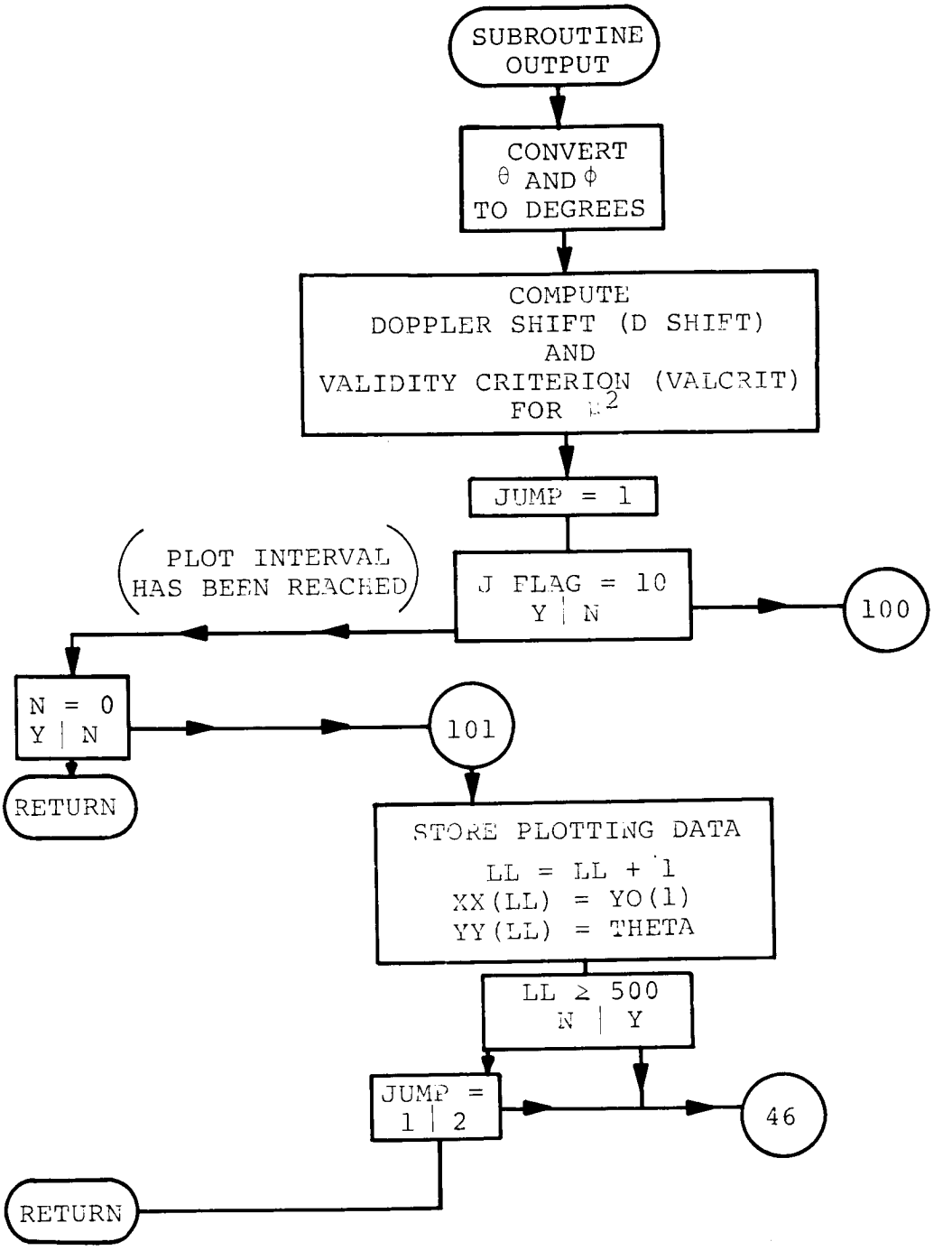


Figure 12A. - Flow Chart of Subroutine OUTPUT

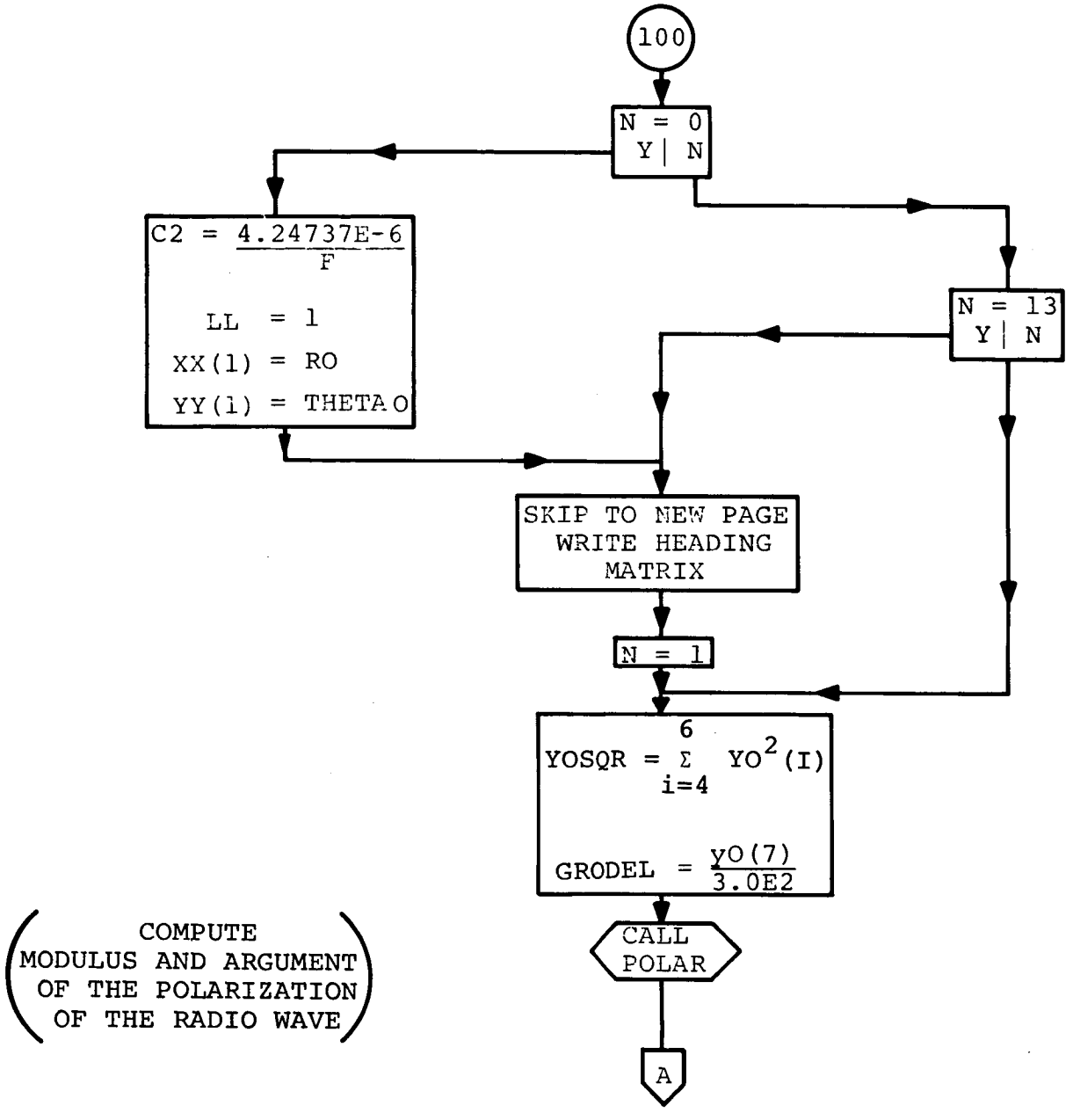


Figure 12B. - Flow Chart of Subroutine OUTPUT

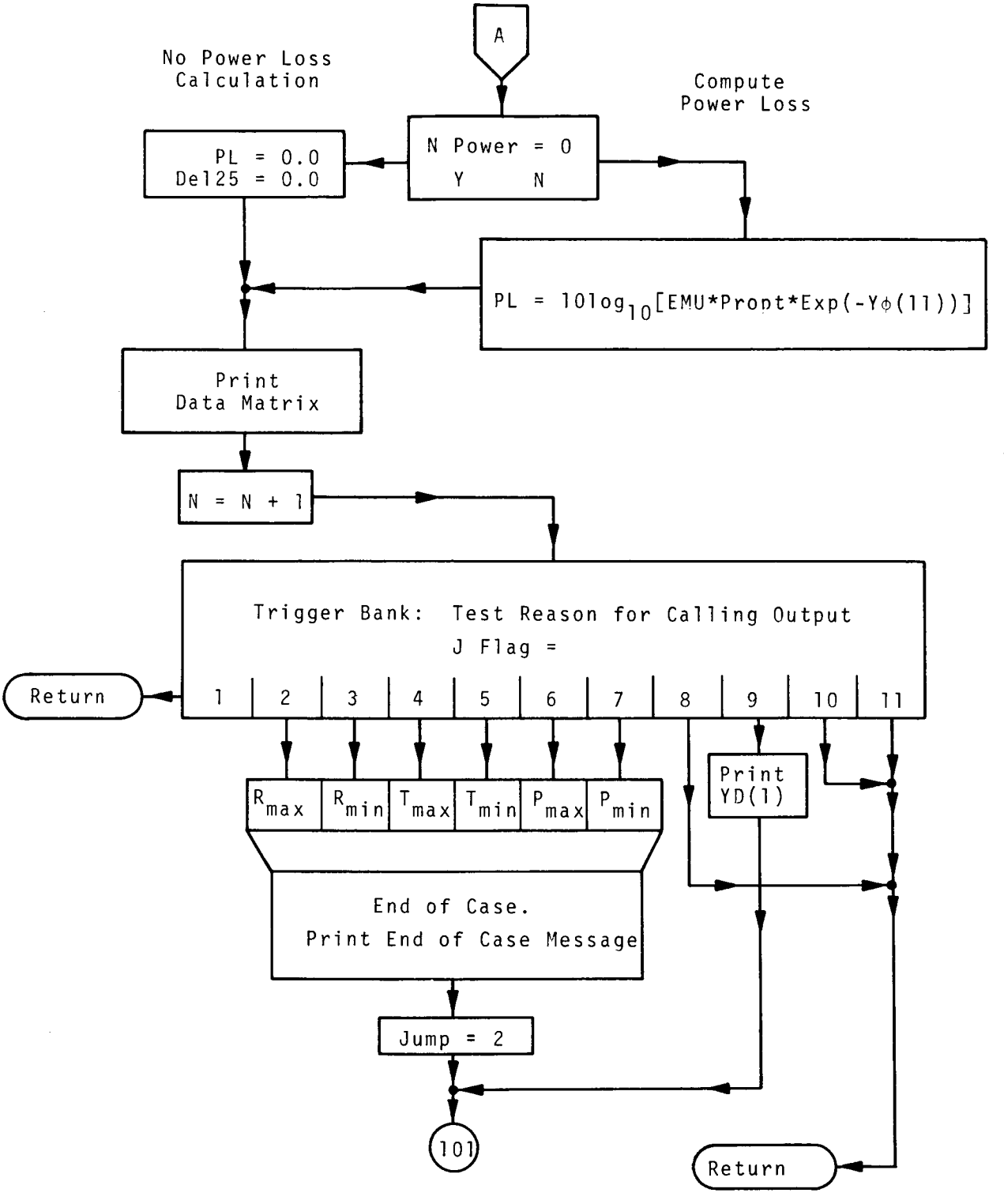
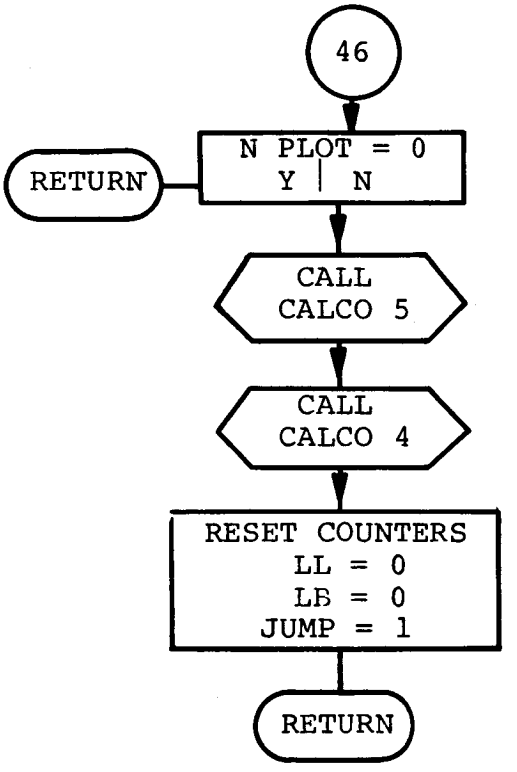


Figure 12C. - Flow Chart of Subroutine OUTPUT



TO GENERATE RECTANGULAR PLOT CALL CALCO 5
TO GENERATE POLAR PLOT CALL CALCO 4

BOTH PLOTS ARE DESCRIBED IN THE FOLLOWING SECTION

Figure 12D. - Flow Chart of Subroutine OUTPUT

altitude consists of three parts that are smoothly joined with the aid of a curve fitting program.

For $6378 \leqslant r \leqslant 6478$ km:

$$\nu' = 12.03527 - 0.07392\ x$$

where

$$x = (r - 6378)\ \text{km}.$$

For $6478 \leqslant r \leqslant 6853$ km:

$$\nu' = \sum_{i=1}^{6} \left[a_i + C(\theta, \phi)\, b_i \right] f_i(x)$$

where

$f_1(x) = 1$; $x = (r-6478)$km

$f_2(x) = x$

$f_3(x) = x^2$

$f_4(x) = x^3$

$f_5(x) = \cos(0.0157\ x)$

$f_6(x) = \sin(0.0157\ x)$

$a_1 = 5.0562$; $b_1 = 0.032512$

$a_2 = -3.7482 \times 10^{-2}$; $b_2 = -0.8847 \times 10^{-2}$

$a_3 = 1.3864 \times 10^{-4}$; $b_3 = 0.8541 \times 10^{-4}$

$a_4 = -1.4777 \times 10^{-7}$; $b_4 = -1.5422 \times 10^{-7}$

$a_5 = -0.48192$; $b_5 = 0.01470$

$a_6 = -0.27021$; $b_6 = 0.65037$

$$c(\theta, \phi) = c_1\theta^2 + c_2\theta + c_3 + (d_1\theta^2 + d_2\theta + d_3)\cos\phi$$

where

$c_1 = -0.35818$; $d_1 = -0.17828$

$c_2 = 1.1250$; $d_2 = 0.55997$

$c_3 = -0.88344$; $d_3 = 0.56028$

θ is the colatitude and ϕ is the longitude in degrees. $\phi = 0$ corresponds to local noon. For $r \geq 6853$ km,

$$\nu' = 2.3653 - 0.0030266\,x \bullet (0.3195 - 0.0000536\,x)\,c(\theta, \phi)$$

where

$$x = (r - 6853)$$

Also, see flow chart of subroutine COLL, Figure 13.

Subroutine FIELD

Description.- An idealized dipole model is used for the magnetic field of the Earth. The magnetic field equations which define gyrofrequency, f_H, and the angle between the magnetic field and the wave normal, ψ, are

$$f_H = c_{11}\left(\frac{a}{r}\right)^3 \left[1 + 3\cos\theta\right]^{1/2}$$

where a = 6378 km, the radius of the Earth and r and θ are the geocentric radius and colatitude of the ray position

$$c_{11} = \frac{e}{2\pi m} B_o \bullet 10^{-6} \doteq 0.9$$

where $B_o = 0.3142$ Gauss is the magnetic field on the surface of the Earth at the equator and e and m are the charge and mass of an electron.

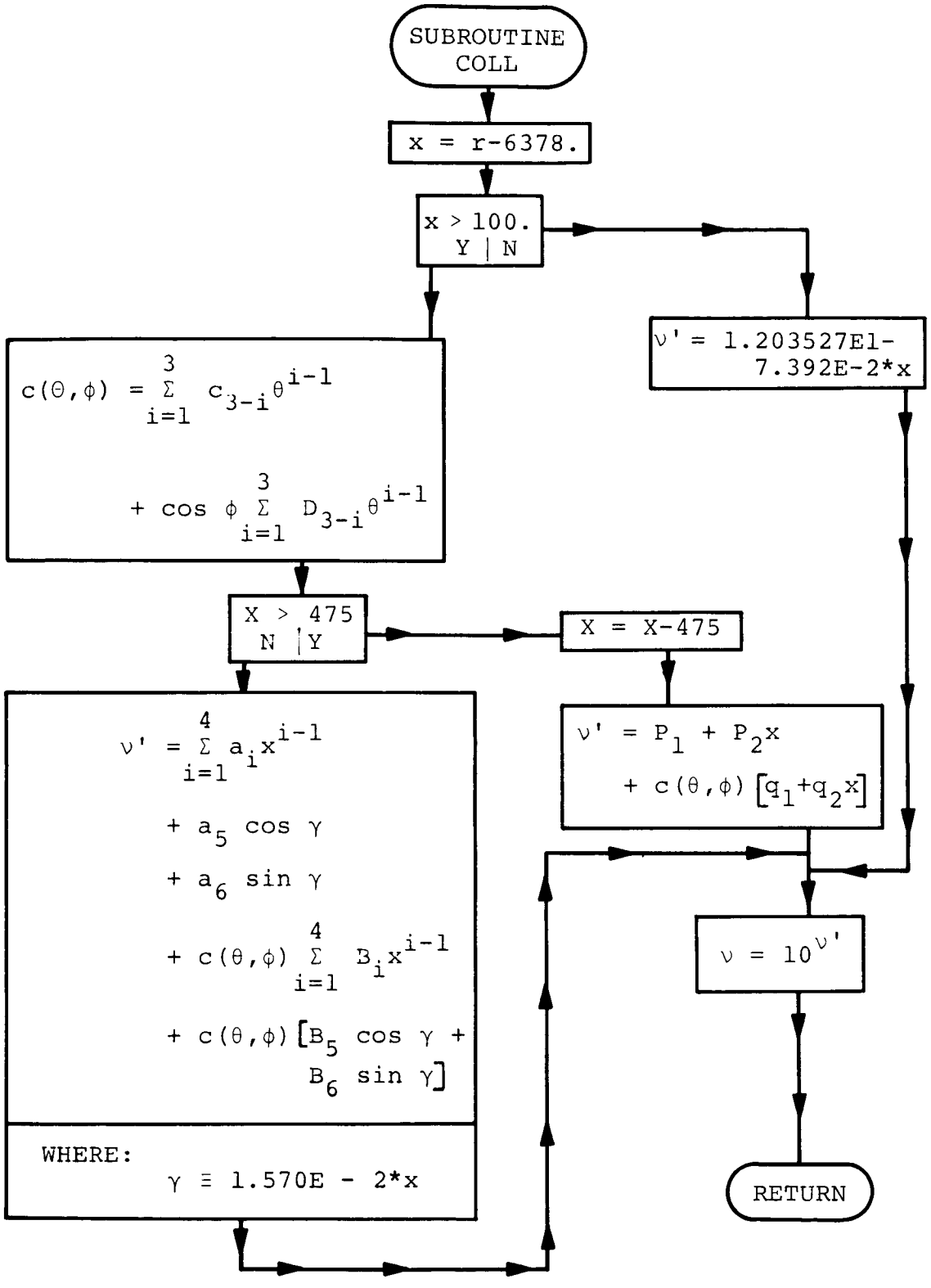


Figure 13. - Flow Chart of Subroutine COLL

$$\cos\psi = \frac{\cos\theta + Y_2 \sin\theta}{\sum_{i=1}^{3} Y_L^2 \bullet \left[1 + 3\cos\theta\right]^{1/2}}$$

$$\sin\psi = \frac{2Y_2\cos\theta - Y_1\sin\theta}{|2Y_2\cos\theta - Y_1\sin\theta|} \left[1 - \cos^2\psi\right]^{1/2}$$

The derivatives of f_H and ψ are:

$$\frac{d(f_H)}{dr} = -2.7 \left(\frac{a^3}{r^4}\right) \left[1 + \cos^2\theta\right]^{1/2}$$

$$\frac{d(f_H}{d\theta} = -2.7 \left(\frac{a^3}{r^3}\right) \frac{\sin\theta\cos\theta}{\left[1 + 3\cos^2\theta\right]^{1/2}}$$

$$\frac{d(f_H)}{d\phi} = 0$$

Let

$$T_1 = \sum_{L=1}^{3} Y_L^2$$

$$T_2 = Y_1\cos\theta + \frac{1}{2} Y_2 \sin\theta$$

$$T_3 = \cos^2\theta + \frac{1}{4} \sin^2\theta$$

$$T_4 = -Y_1\sin\theta + \frac{1}{2} Y_2\cos\theta$$

Then

$$\frac{d(\cos\psi)}{dr} = 0$$

$$\frac{d(\cos\psi)}{d\theta} = \frac{T_4 + \frac{3}{4}\left[\frac{T_2 \sin\theta\cos\theta}{T_3}\right]}{(T_1)^{1/2} \bullet (T_3)^{1/2}}$$

$$\frac{d(\cos\psi)}{d\phi} = 0$$

$$\frac{d(\cos\psi)}{dY_1} = \frac{\cos\theta - \left[\frac{Y_1 \bullet T_2}{T_1}\right]}{(T_1)^{1/2}(T_3)^{1/2}}$$

$$\frac{d(\cos\psi)}{dY_2} = \frac{\frac{1}{2}\sin\theta - \left[\frac{Y_2 \bullet T_2}{T_1}\right]}{(T_1)^{1/2}(T_3)^{1/2}}$$

$$\frac{d(\cos\psi)}{dY_3} = \frac{-Y_3\cos\psi}{T_1}$$

$$\frac{d^2(\cos\psi)}{dY_2\, d\theta} = -\frac{d(\cos\psi)}{d\theta}\,\frac{Y_2}{T_1} + \frac{4\cos\theta}{(T_1)^{1/2}(T_3)^{1/2}\left[1 + 3\cos^2\theta\right]^2}$$

$$\frac{d^2(\sin\psi)}{dY_2\, d\theta} = -\frac{1}{\sin\psi}\left[\cos\psi\,\frac{d^2(\cos\psi)}{dY_2\, d\theta} + \frac{d(\cos\psi)}{d\theta}\,\frac{d(\cos\psi)}{dY_2} \bullet \frac{1}{\sin^2\psi}\right]$$

Also, see flow chart, Figure 14.

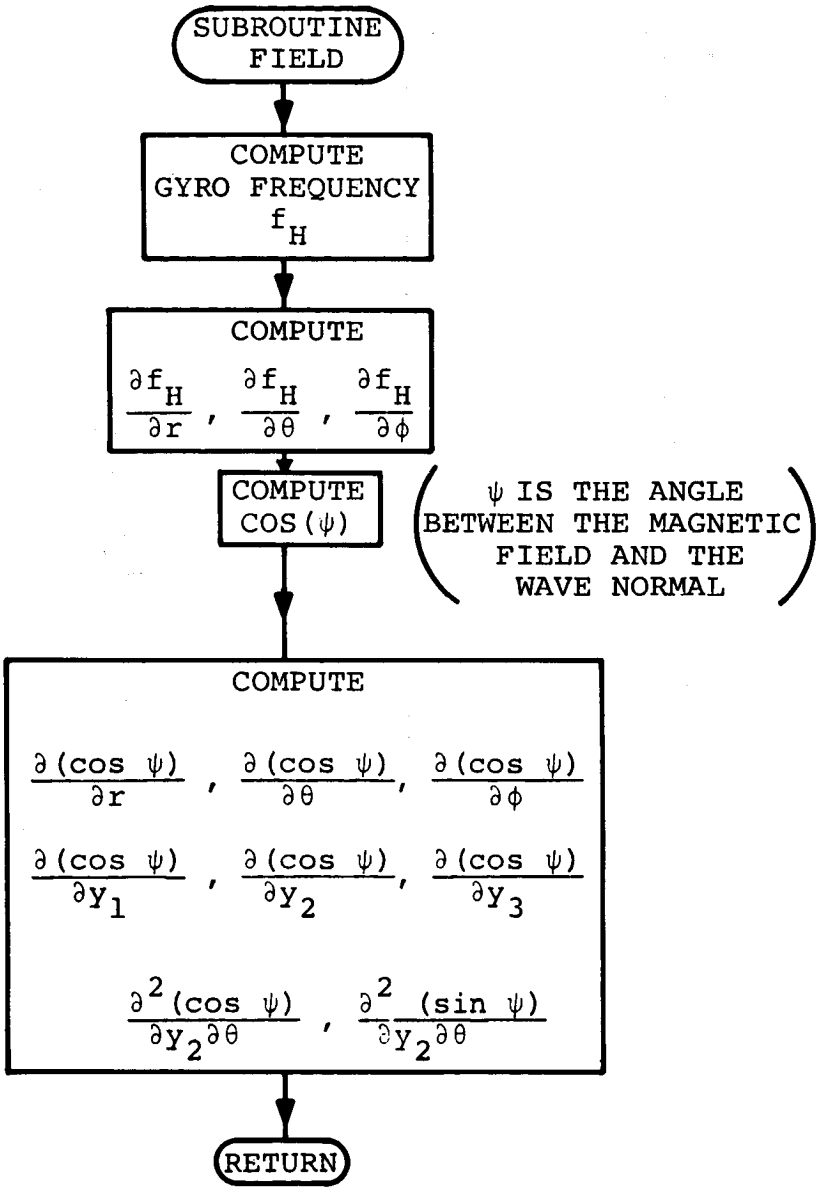


Figure 14. - Flow Chart of Subroutine FIELD

Dictionary of major FORTRAN names.- Table XII contains a dictionary of major FORTRAN names, subroutine FIELD.

TABLE XII

FORTRAN Name	Definition
FH	f_H, gyrofrequency in MHz
DFHDR	$\frac{d(f_H)}{dr}$
DFHDQ	$\frac{d(f_H)}{d\theta}$
DFHDP	$\frac{d(f_H)}{d\phi}$
COSPSI	$\cos(\psi)$
SP2	$1 - \cos^2(\psi)$
DCPDR	$\frac{d(\cos\psi)}{dr} = 0$
DCPDT	$\frac{d(\cos\psi)}{d\theta}$
DCPDP	$\frac{d(\cos\psi)}{d\phi} = 0$
DCPDY1	$\frac{d(\cos\psi)}{dY_1}$

TABLE XII.- Concluded

FORTRAN Name	Definition
DCPDY2	$\frac{d(\cos\psi)}{dY_2}$
DCPDY3	$\frac{d(\cos\psi)}{dY_3}$
D2CY2T	$\frac{d(\cos\psi)}{d(Y_2)d(\theta)}$
D2SY2T	$\frac{d(\sin\psi)}{dY_2\, d\theta}$

Subroutine DENSE

Description.- The electron density is given by

$$N(r,\theta,\phi) = N_1(r,\theta) \bullet N_2(r,\theta,\phi)$$

where r is the geocentric radius, θ is the colatitude, and ϕ is the magnetic longitude.

$N_1(r,\theta)$ represents the background density in the magnetic meridional plane and $N_2(r,\theta,\phi)$ represents the ionization of the field-aligned irregularities in both the meridional and azimuthal planes.

The background ionization is assumed to have the form:

$$N_1(r,\theta) = N_F + N_x$$

where

N_F = electron density in the F-region

N_x = electron density in the exosphere

$$N_F = N_{max} * EXP\left[1/2 \left\{ 1-W-e^{-W} \right\}\right]$$

N_{max} is assumed to be 2.7E5

and

$$W = \frac{h-h_{max}}{H_F}$$

h_{max} = altitude of the peak electron density N_{max}

H_F = the scale height

h_{max} = 350 km

H_F = 50 km

The electron density in the exosphere is given by:

$$N_x = N_r \times [1.659E3 \bullet \theta + 1.662E4]$$

where θ is the colatitude in radians.

$$N_r = \left[\sum_{i=1}^{3} \beta_i \exp\left(-\frac{Z_x}{H_i} \right) \right]^{1/2}$$

where Z_x is the geopotential altitude given by:

$$Z_x = \frac{r_o}{r} (r-r_o)$$

where r_o is the reference radial distance and is equal to 6878 in the model.

The symbol i refers to each ion present in the exosphere. H_i and β_i refer to the scale height and the fractional density of the i-th ion at the reference level r_o.

A three-ion gas model consisting of oxygen (O^+), helium (He^+), and hydrogen (H^+) ions is assumed. The various parameters in the density equation have the following values:

ion_i	β_i	H_i
O^+	.9788	66.546
H^+	.0016	1056.3
He^+	.0196	265.98

The technique suggested by Swayze is used to join the exospheric profile smoothly with that of the F-layer between 350 and 1000 km. The expression N_x is modulated by a factor

$$\text{EXP}\left[-\left(\frac{h-1000}{500}\right)^2\right]$$

where h is the altitude in km.

The model for the field aligned ionization irregularities is given by:

$$N_2(r,\theta) = 1 + \frac{\Delta N_o}{\left(N \bullet \frac{t}{t_o}\right)} \bullet \text{EXP}\left[-\left(\frac{\Delta z}{H_o\left(\frac{t}{t_o}\right)}\right)^2\right]$$

N_o is the peak ionization enhancement and H_o is the scale size of the irregularity at the base of the field line

$$\frac{t}{t_o} = \frac{\text{meridional width at } (r,\theta)}{\text{meridional width at } (r_o,\theta_o)}$$

$$= \frac{\sin^3\theta(4-3\sin^2\theta_o)^{1/2}}{\sin^3\theta_o(4-3\sin^2\theta)^{1/2}}$$

$$N_F = N_{max} \bullet \exp\left[\frac{1}{2}\left(1-W-e^{-W}\right)\right]$$

$$\frac{dN_F}{dr} = N_F \bullet \left(-\frac{1}{2H_F}\right)\left(1-e^{-W}\right)$$

Since $H_F = 50$ km

$$\frac{dN_F}{dr} = N_F \times 10^{-2}(e^{-W}-1)$$

$$\frac{dN_F}{d\theta} = 0$$

$$N_x = N_r[K_1\theta + K_2]$$

where K_1 and K_2 are constants and θ is the colatitude.

$$N_r = \left[\sum_{i=1}^{3} \beta_i \exp\left(- \frac{Z_x}{H_i} \right) \right]^{1/2}$$

where

$$Z_x = \frac{r_o}{r} (r - r_o)$$

$$\frac{dN_x}{dr} = - \frac{(K_1\theta + K_2)}{2N_r} \left[\sum_{i=1}^{3} \frac{\beta_i}{H_i} \exp\left(- \frac{Z_x}{H_i} \right) \right] \frac{dZ_x}{dr} .$$

But,

$$\frac{dZ_x}{dr} = \frac{r_o^2}{r^2}$$

$$\frac{dN_x}{dr} = - \frac{(K_1\theta + K_2)}{2N_r} \cdot \frac{r_o^2}{r^2} \left[\sum_{i=1}^{3} \frac{\beta_i}{H_i} \exp\left(- \frac{Z_x}{H_i} \right) \right]$$

$$\frac{dN_x}{d\theta} = K_1 N_r .$$

If N_x is modulated by the factor

$$F_r = \exp\left[- \left(\frac{r-7378}{500} \right)^2 \right]$$

for r < 7378 km.

$$\frac{dN_x'}{dr} = \frac{d(N_x \cdot F_r)}{dr} = \frac{dN_x}{dr} \bullet F_r + N_x \frac{dF_r}{dr} .$$

$$\frac{dF_r}{dr} = F_r \bullet \left(\frac{7378-r}{125000} \right)$$

Similarly,

$$\frac{dN_x'}{d\theta} = \frac{d(N_x \cdot F_r)}{d\theta} = F_r \bullet \frac{dN_x}{d\theta}$$

$$= K_1 N_r \bullet F_r$$

DIS refers to the normal distance of the ray-position (r,θ,ϕ) from a field-line of colatitude λ.

$$DIS = r \bullet \frac{\left(1 - \frac{a}{r}\frac{\sin^2\theta}{\sin^2\lambda}\right)}{\left(1 + \frac{4}{\tan^2\theta_1}\right)}$$

where

$$\theta_1 = \theta + \left\{1 - \frac{a}{r} \bullet \frac{\sin^2\theta}{\sin^2\lambda} \frac{\frac{2}{\tan\theta}}{\left(1 + \frac{4}{\tan^2\theta}\right)}\right\}$$

SOA refers to the geometrical path length in Earth radii of any arbitrary ray-position (r,θ) from its initial position (r_o,θ_o) along the same magnetic field line of the colatitude λ.

$$SOA = \frac{\sqrt{3}}{\sin^2\lambda}\left[\left(\frac{4}{3} - \sin^2\theta\right)^{1/2}\cos\theta - \left(\frac{4}{3} - \sin^2\theta_o\right)^{1/2}\cos\theta_o + \frac{1}{3}\log\left|\frac{\left(\frac{4}{3} - \sin^2\theta\right)^{1/2} + \cos\theta}{\left(\frac{4}{3} - \sin^2\theta_o\right)^{1/2} + \cos\theta_o}\right|\right]$$

Also, see flow chart, Figure 15.

Dictionary of major FORTRAN names.- Table XIII contains a dictionary of major FORTRAN names, subroutine DENSE.

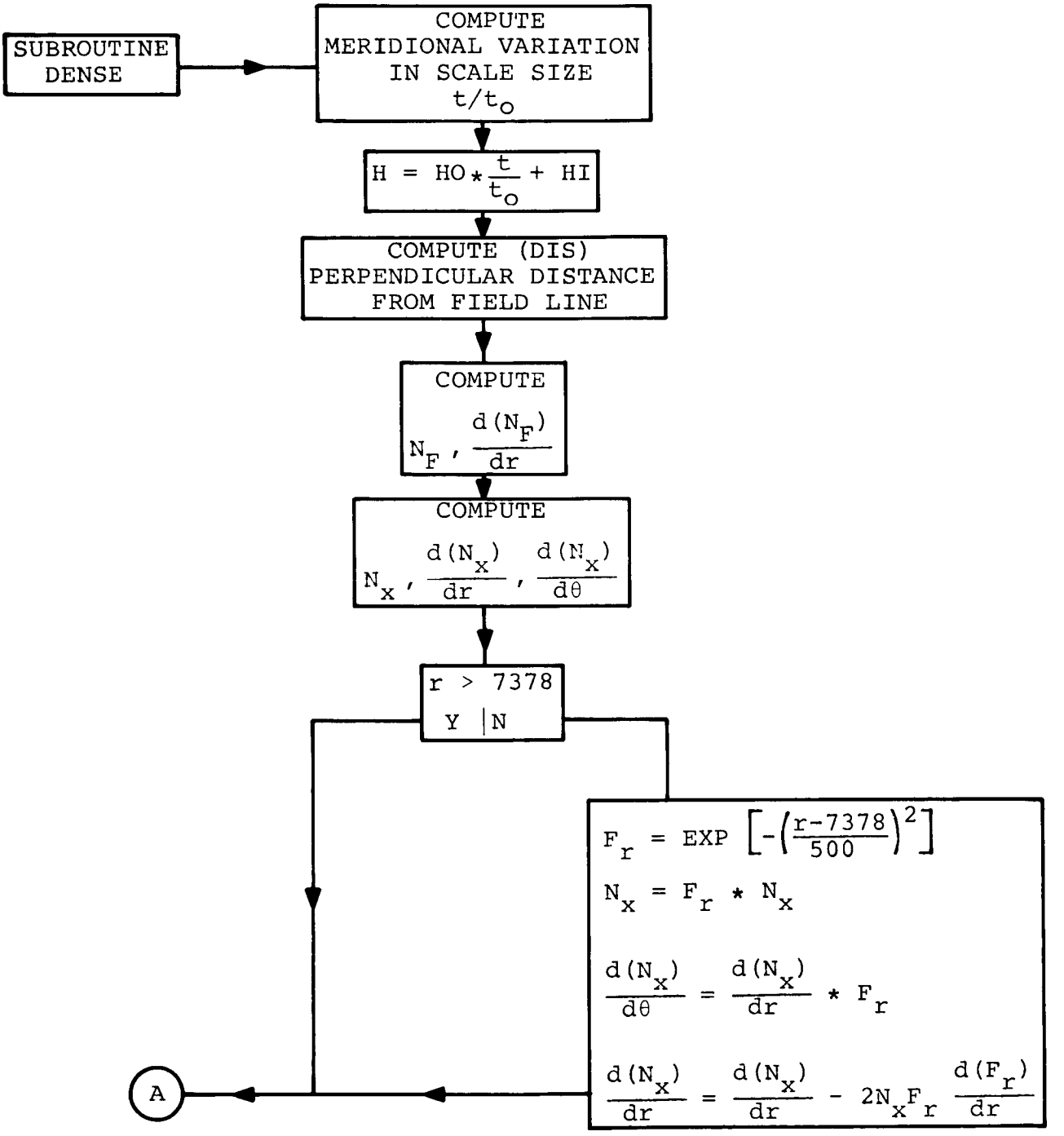


Figure 15A. - Flow Chart of Subroutine DENSE

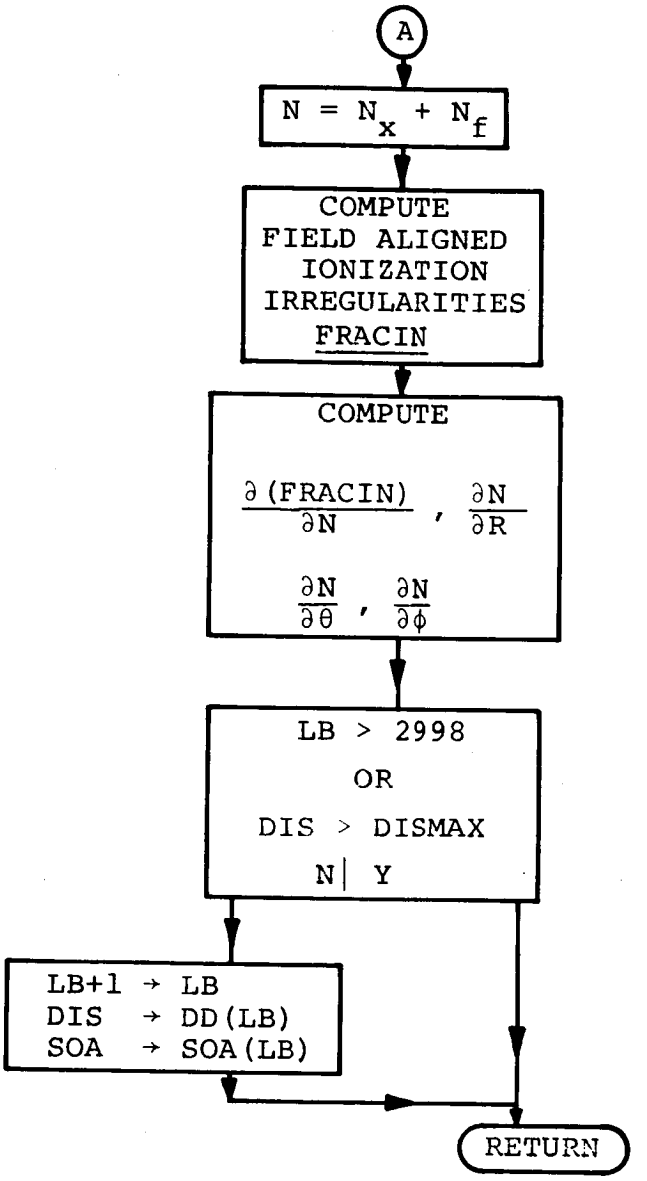


Figure 15B. -- Flow Chart of Subroutine DENSE

TABLE XIII

FORTRAN Name	Data Type	Definition
ENF		N_F - Electron density in the F-region
ENX		N_X - Electron density in the exosphere
ZX		$\frac{r_o}{r}(r - r_o)$ - geopotential altitude
ENXR		$\Sigma\beta_i \bullet EXP\left(-\frac{Z_x}{H_i}\right)$
DZXDR		$\frac{d(Z_x)}{dr}$
DENFDR		$\frac{d(N_F)}{dr}$
DENXDR		$\frac{d(N_x)}{dr}$
DENXDT		$\frac{d(N_x)}{d\theta}$
R	r	Geocenter radius of wave front, in km
TH	θ	Colatitude of wave front, in radians
AMBDA	λ	Colatitude of point where the field line intersects the Earth's surface, in radians

TABLE XIII.- Concluded

FORTRAN Name	Data Type	Definition
ZM5	$\frac{t}{t_o}$	$\frac{\text{meridional width at } (r,\theta)}{\text{meridional width at } (r_o,\theta_o)}$ } modulation factor if variable width duct is considered
H	$\frac{t}{t_o} H_o$	Scale size of the field line at (r,θ,ϕ)
DIS		Distance perpendicular from (r,θ,ϕ) to field line
DD		Plotting array used to store distance from field line, DIS
SØA		Plotting array used to store distance along field line

Subroutine CALCØ5

Description.- This subroutine does the plotting for tne ray tracing program. All plotting operations are performed by this routine.

Two types of plot are generated by this program. The first is a rectangular plot of distance from the field line vs. distance along the field line from near end. The polar plot shows the total ray path with respect to the Earth. All distances are in kilometers.

Multiple entry points allow the user to obtain either one or both of the plots. The user also has the option of overlaying successive plots.

This subroutine has entry points CALCO4 and CALCO5 in subroutine OUTPUT. CALCOl, CALCO2 and CALCO3 are called by INPUT.

This subroutine in turn calls subroutine AXIS, SYMBOL, NUMBER, LINE and PLOT. These are standard calcomp plotting subroutines and are described in Bulletin #170-C, Programming for Calcomp Digital Incremental Plotters, by California Computer Products, Inc.

The subroutine PRAM calculates the adjusted minimum and delta required by the line and axis subroutines.

Restrictions of CALCO4

Titling - Because only one set of axes is drawn, when using the overlay option, titling information for the overlayed plots is not printed. The user should know beforehand the content of the plot.

Also, see flow chart, Figure 16.

Dictionary of major FORTRAN Names.- Table XIV contains a table of major FORTRAN names, subroutine CALCO5.

TABLE XIV

FORTRAN Name	Data Type	Definition
PLDAT	Numeric array	Working storage for plot subroutine
X	Numeric array	X coordinates to be plotted
Y	Numeric array	Y coordinates to be plotted
LL	Scalar	Number of points in X and Y arrays
DATE	Alphanumeric array	20 characters reserved for data
PLT	Numeric array	Numeric values of labling information
XMAXO XMINO	Scalar	Maximum and minimum values of the X-axis for the rectangular plot of the distance from the field line vs. the distance along the field line
YMAXO YMINO	Scalar	Maximum and minimum values of the Y-axis for the rectangular plot of the distance from the field line vs. the distance along the field line
XMAX1 XMIN1	Scalar	Maximum and minimum values of the X-axis for the polar plot of ray path
YMAX1 YMAX1	Scalar	Maximum and minimum values of the Y-axis for the polar plot of ray path

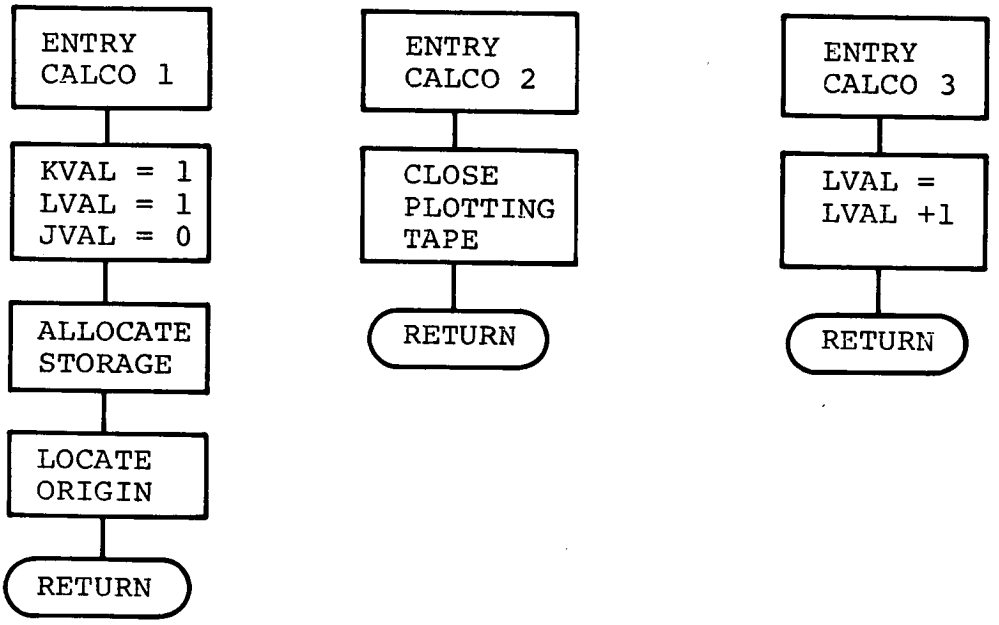


Figure 16A. - Flow Chart of Subroutine CALCO

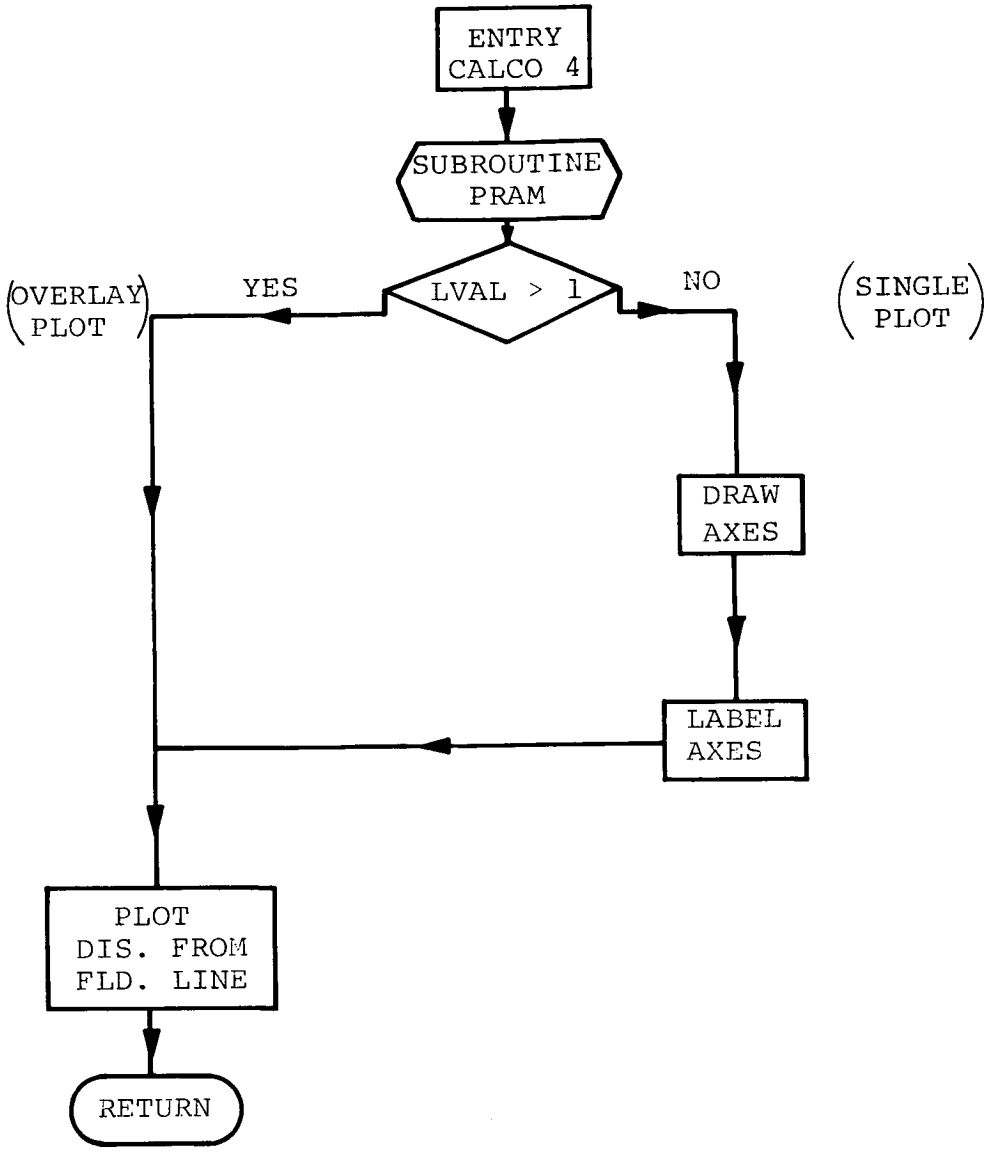


Figure 16B. - Flow Chart of Subroutine CALCO

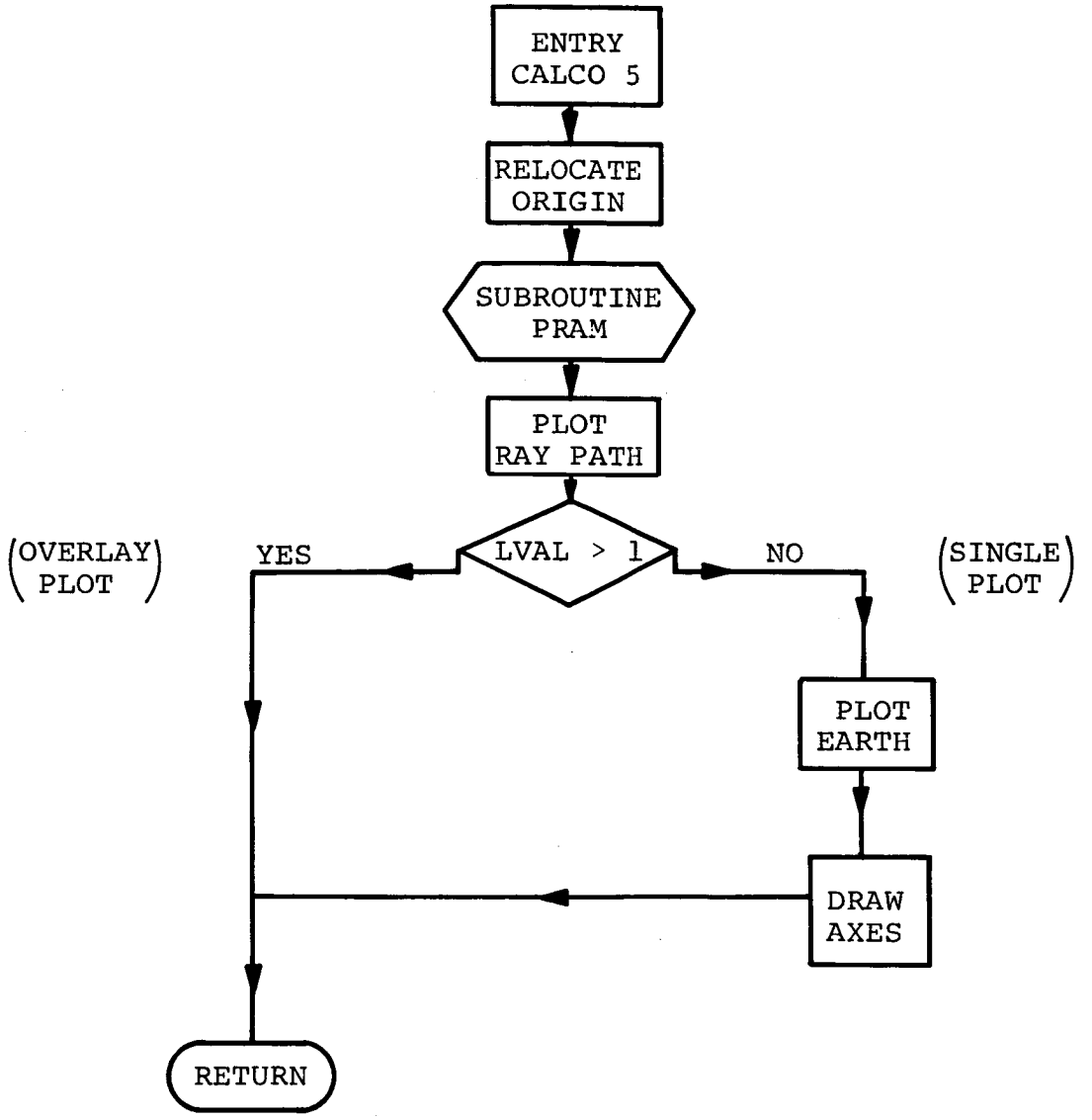


Figure 16C. - Flow Chart of Subroutine CALCO

Subroutine FORCE

Description.- Subroutine FORCE solves the equation.

$$Y_1^2 + Y_2^2 + Y_3^2 = \mu^2 \ .$$

In theory this relationship holds all along the ray path but in fact it does not. We make it hold by scaling Y_1, Y_2 and Y_3 down proportionately. This process is called "Normalization" of the Y vector. FORCE is called by MAIN only.

Also see flow chart, Figure 17.

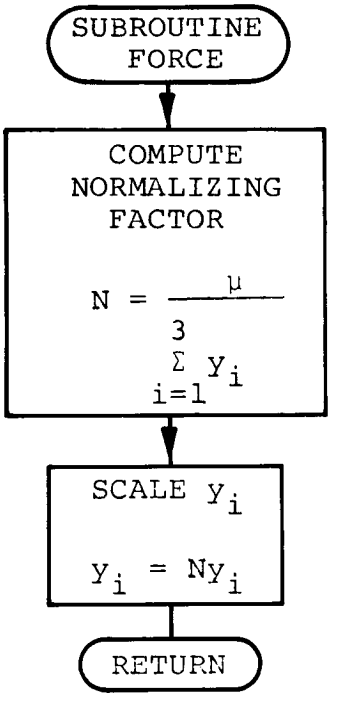


Figure 17. - Flow Chart of Subroutine FORCE

Subroutine POLAR

Description.- The expression $R = E_{\bar{x}}/E_{\bar{y}}$, a complex number, is the polarization term. $E_{\bar{x}}$ and $E_{\bar{y}}$ are the components of the electric vector of the wave along axes $(\bar{x},\bar{y})$ in the wave front, $\bar{y}$ being in and $\bar{x}$ perpendicular to the plane containing the magnetic field of the Earth.

$$|R| = \text{modulus of } R = \frac{1}{Y_L}\left[\frac{\frac{1}{4}Y_T^4 + A \pm Y_T^2 A^{1/2}\cos\frac{\theta}{2}}{d}\right]^{1/2}$$

$$\Phi = \text{argument of } R = \tan^{-1}\frac{-\frac{1}{2}(1-X)Y_T^2 \pm A^{1/2}\left(\cos\frac{\theta}{2}(1-X) - Z\sin\frac{\theta}{2}\right)}{\frac{1}{2}ZY_T^2 \pm A^{1/2}\left(\sin\frac{\theta}{2}(1-X) + Z\cos\frac{\theta}{2}\right)}$$

$$d = (1-X)^2 + Z^2$$

$$A = \left\{\left[\frac{1}{4}Y_T^4 + Y_L^2 d\right]^2 + \left[2ZY_L^2(1-X)\right]^2\right\}^{1/2}$$

where

$$\theta = \tan^{-1}\left\{\frac{-2(1-X)\,Z\,Y_L^2}{\frac{1}{4}Y_T^4 + Y_L^2 d}\right\}$$

Also, see flow chart, Figure 18.

Mathematical Subroutines

CST1 and TOR.- CST1 evaluates the sine and cosine integrals $S_i(x)$ and $C_i(x)$. It is called only in MAIN and in turn calls TOR. TOR evaluates n! and is called only by CST1.

Minv.- MINV solves three sets of three simultaneous equations using a Gaussian method with pivot selection. It is called by POWERL and calls no other subroutine.

SMARK and MARK.- Subroutines SMARK and MARK constitute the integration package. MARK is a MAP language subroutine originally written by the Jet Propulsion Laboratory. The purpose of SMARK is to allow an interface with the main program written in FORTRAN IV.

Listings of the five mathematical subroutines are appended in Appendix B. A complete description of the integration package is found in Appendix A.

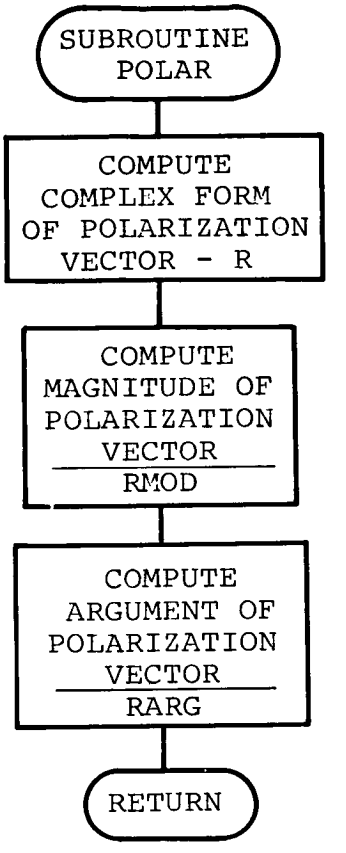


Figure 18. - Flow Chart of Subroutine POLAR

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APPENDIX A

DESCRIPTION OF THE INTEGRATION PACKAGE

Introduction

The integration package is composed of two subroutines, SMARK and MARK, both written in the MAP assembly language. Subroutine SMARK serves as a connecting link between the FORTRAN IV monitor and subroutine MARK. Subroutine MARK as originally written was designed to operate in a non-FORTRAN environment. The integration of the differential equations is performed by MARK.

Subroutine SMARK

This subroutine is buffer between MARK, a differential equation solving routine written in MAP language, and a main program written in FORTRAN. SMARK allows a program written in FORTRAN IV to use most of the features of MARK.

Usage of SMARK.- A knowledge of MARK is assumed.

Calling sequences:

CALL SMARK, KIND, N.HBANK, NRTN, NTRG

EUBAR, ELBAR, HMAXT, HMINT, YCLOW

LV1, TV1,

LV2, TV2,

LV3, TV3, etc.,

. . . . . up to 10 triggers

where

KIND = type of integration

0 = fixed AM integration

2 = RK integration

4 = Variable Adams-Moulton integration

N = actual number of differential equations

HBANK = location of a bank of storage used by MARK equivalent to HBANK-3

NRTN = return indicator from SMARK

1 = EOS

2 = DER1

3 = DER2

4 = trigger return

5 = error return

NTRG = return indicator from SMARK which designates which trigger has been activated. 1 for first trigger, 2 for second, etc.

EUBAR, ELBAR, HMAXT, HMINT, YCLOW same as in MARK

LV1 = location of variable being tested

TV1 = location of desired value of the variable tested

CALL TRA14 returns control to SMARK and causes a TRA 1,4 return to MARK.

CALL TRA24 returns control to SMARK and causes a TRA 2,4 return to MARK.

CALL ON (N) turns trigger N on.

CALL OFF (N) turns trigger N off.

The order of the differences to be carried in the Adams-Moulton integration must be stored in HBAND(1), the nominal step size in HBAND(4), the maximum number of equations allowable in HBANK(5), and all independent and dependent variables initialized before calling SMARK. The double precision part of the independent variable HBANK(7) is set to zero by SMARK.

Subroutine MARK

MARK is a closed subroutine designed to solve the first n of a set, N, of first-order differential equations utilizing Adams-Moulton open or open and closed formula types. A Runge-Kutta fourth-order integrator is used as a starting routine to generate backward differences initially. Provision is made for interrupting the integration process at specific values of either the independent or the dependent variables. The order of differences (m) used in the Adams-Moulton mode is less than or equal to nine (9) ($m \leqslant 9$).

Restrictions.- The following restrictions to subroutine MARK apply:

(1) MARK will not integrate backwards in the independent variable. The nominal step size, H, must be positive. Changes in H must be accomplished by the use of a "doubling" or "halving" procedure in MARK that will double (set H = 2H) or halve (set H = 0.5H) the integration step size.

(2) Underflow and overflow are not checked internally.

(3) The user must provide the necessary interruption subroutines, an auxiliary program to evaluate the n first-order derivatives, and a bank of storage for internal calculation.

(4) This is an FAP program and is not FORTRAN compatible.

Integration technique.- The following integration technique applies:

(1) MARK permits the user to solve the N differential equations by one of three options:

a. Runge-Kutta fourth order.

b. Adams-Moulton with a fixed step size, H, and the ability to alter H by the doubling and/or halving procedure using Runge-Kutta to initially generate backward differences. This applies to either a predictor or a predictor with q corrections (open or open and closed type formulas).

c. Adams-Moulton as mentioned in b. using an automatic variable step size control. Halving and doubling are controlled automatically. The correction formula is applied only once.

(2) Both the independent and the dependent variables are automatically carried internally in partial double precision to control round-off error locally. The user, however, will recognize the variables only as single precision quantities. However, the user may carry the independent variable in full double precision by option.

Usage of MARK.- The following usage of MARK applies:

Calling Sequence:

```
CALL MARK or TSX $MARK,4
PZE HBANK, P, EOS
PZE DERI, ϕ, DER2
ERROR RETURN
Pfx B1,,Y1
PZE Z1
Pfx B2,,Y2
PZE Z2
.
.
.
Pfx BJ,,YJ
PZE ZJ
PZE O
```

where the symbols are defined as follows:

HBANK - The location of a bank of storage to be described below.

O - The independent variable is carried in partial precision.

P - double precision (single precision to the user).

1 - The independent variable is carried in full double precision.

EOS - The location of a user "end of step" routine. This routine must terminate with a TRA 1,4 command. It is used to evaluate variables that are needed only after a full integration step is completed.

DER1 - The location of the entry to the user's derivative routine that carries out all calculations that involve the independent variable. This routine must terminate with a TRA 1,4 command.

DER2 - The location of the entry to that portion of the user's derivative routine that carries out all calculations that do not involve the independent variable but are required to evaluate the derivatives.

A simple example of the use of DER1, DER2 follows:

Suppose we are to solve

$$\frac{dy}{dx} = ax^2 + by$$

then

DER1 ax^2

Thus, the DER1 entry calculates the extra term involving the independent variable x. This provides a saving of real machine time, particularly during the Runge-Kutta phase of integration, and also saves machine time when the closed type formula is used with Adams-Moulton integration.

0 - Adams-Moulton integration with fixed step size

ϕ = 2 - Runge-Kutta integration only

4 - Adams-Moulton using automatic variable step size control

The pairs of locations in the calling sequence are specified as:

Pfx BJ,,YJ

PZE ZJ are defined as "triggers"

These triggers are the linkage control to the user's interruption subroutines. The triggers state that control is transferred to location BJ when the contents of location YJ are equal to the contents of location ZJ. Thus BJ is the location of a user's interruption subroutine, YJ is the location of a variable being checked, and ZJ is the location that contains the desired value for YJ.

Triggers are separated into two classes: Independent variable triggers called T-stops and dependent variable triggers called Y-stops.

(1) Independent variable triggers called T-stops. These triggers interrupt on values of the independent variable of integration. All T-stops must have YJ = 0. That is, they must have the following format in the calling sequence:

Pfx BJ

PZE ZJ

The logic used to execute T-stops is as follows:

Let t_{s1}, t_{s2}, t_{s3}.....t_{sk} be a set of values of the independent variable for which interruptions are desired.

MARK sets t_m = Min $[t_{s1}, t_{s2},.....t_{sk}]$. Integration continues normally until the independent variable reaches the condition:

$$t_\eta < t_m \leqslant t_\eta + 1$$

The step size is set = $(t_{\eta + 1} - t_m)$ and integration is carried to t_m where all the values of the variables including derivatives and end of step values are calculated and control is then transferred to the user's interruption routine, all values are reset to station $t_{\eta-1}$ and the next t_m is determined. If no other t_m exists within this step, integration continues. Thus, interruption routines for all t_m within a given step are executed before integration continues. There is no limitation on the number of T-stops permitted (except for machine size, of course).

(2) Dependent variable triggers called Y-stops. These triggers are interrogated at the beginning of an integration step and a value.

$$i_j = y_\eta = y_j$$

is calculated and saved for each of the j Y-stops. At the end of the integration step the difference,

$$r_j = y_{\eta + 1} - y_j$$

is calculated and the algebraic sign of r_j is compared to l_j:

If

$$\text{sgn } l_j \neq \text{sgn } r_j$$

then the condition $y = y_j$ has occurred within the integration step and a linear interpolation search procedure is executed to determine the value of the independent variable, t, such that $y = y_j$. When the Δt calculated by the search procedure is such that

$$\Delta t < \delta_u$$

where

$$\delta_u = \begin{cases} 2^{-26} \text{ Max } H, t_{\eta+1} & \text{for } P = 0 \\ 2^{-42} \text{ Max } H, t_{\eta+1} & \text{for } P = 1 \end{cases}$$

then convergence to t_j is assured. At this point all values of the dependent variable including their respective derivatives and any end-of-step calculations are determined and control for the corresponding Y-stop is returned to the user's interruption routine. If more than one Y-stop trigger occurs within an integration step, then the triggers are executed in the order of the smallest value of the independent variable determined for the respective Y-stops. Thus, the order of execution is determined by the independent variable. After all Y-stops within an integration step have been determined and executed, the conditions at station $t_{\eta+1}$ are restored for all dependent variables and their derivatives and end-of-step calculations, if any. Integration then continues normally.

Up to and including 50 dependent variable triggers are permitted. However, this number may be altered by changing the symbolic card "OMAR EQU 50" in the symbolic program deck to the desired number.

It remains to define Pfx of the trigger pair. This is utilized to permit the user to render triggers "active" or "inactive". Active means that a trigger is to be interrogated and executed if necessary. Inactive means that the trigger is to be ignored.

Thus, if

$$\text{Pfx} = \begin{matrix} \text{PZE} = \text{trigger is active} \\ \text{MZE} = \text{trigger is inactive.} \end{matrix}$$

The interruption routines provided by the user must terminate with either a TRA 1,4 command or a TRA 2,4 command.

TRA 1,4 is used when the interruption does not constitute a discontinuity in any of the calculations.

TRA 2,4 is used when a discontinuity exists. Under this condition a "restart" procedure is initiated by MARK by continuing beyond the discontinuity point using Runge-Kutte until a sufficient number of backward differences are determined to switch to Adams-Moulton integration.

Comments on triggers.- The following are comments on triggers:

(1) There is no limitation on how many times a trigger may be executed.

(2) Care must be exercised in updating the ZJ of triggers. If the ZJ are not updated after a trigger returns control to the user, a machine loop will result, since MARK will continue to return control to the user, a machine loop will result, since MARK will continue to return control to the user's respective interrupt routine on the basis of the current ZJ. Thus, a trigger must either be updated or rendered inactive to looping.

(3) In all cases where more than one trigger is to be executed at a single point (t_j) the triggers will be executed in order of their ascending appearance in calling sequence

(4) Control is returned to the error return of the calling sequence whenever $t_m < (t_\eta - \delta_u)$ or when the number of Y-steps exceeds 50.

The entire list of triggers must be terminated with PZE 0. This is the end of the calling sequence for MARK.

The bank of storage specified by the location HBANK is as follows:

```
        PZE m

        PZE NH

        PZE ND

HBANK

        DEC H

        PZE N,,n

        DEC t1

        DEC t2
```

DEC y_1

DEC y_2

.

.

.

DEC y_n

.

.

.

DEC y_N

DEC y'_1

DEC y'_2

.

.

.

DEC y'_n

.

.

.

DEC y'_N

. $3N + 2N(m + 1)$ for ϕ 0,2

BSS

$5N + 3N(m + 2)$ for ϕ 4

where

m = order of differences to be carried in the Adams-Moulton mode.

$m \leq 9$ (fixed point in the address portion of the word) for $\phi = 0$.

$m \leq 8$ for $\phi = 4$.

NH = number of times to sequentially halve the step size in the Adams-Moulton mode (fixed point in the address portion of the word).

NOTE

NH takes precedence over ND and doubling is not executed until the number of times to halve is completed. If these numbers are introduced initially in the HBANK, the procedure is commenced automatically when conversion from Runge-Kutta to Adams-Moulton is completed. NH and ND are ignored when using the automatic variable step size mode. NH and ND may be set by dependent variable or independent variable interruption routines in the Adams-Moulton fixed mode. Control is returned to the user anytime through an interruption routine. The number of times halving and/or doubling have/has been completed is available in the decrement portion of NH and/or ND. If additional halving and/or doubling requests are entered in the address portions of NH and/or ND before a preceding request is completed, the sum of the additional request and those remaining uncompleted will be executed.

H = nominal step size (floating point).

N = total number of 1st order differential equations (fixed point).

n = total number of the first n 1st order differential equations to be integrated by MARK. $n \leq N$ (fixed point).

NOTE

H and N must not be altered unless a restart procedure is executed after

the inital entry to MARK. Item n may be altered after the inital entry to MARK through an interruption routine. If n is increased, MARK restarts. Care should be exercised in setting the initial conditions corresponding to the additional equations to be integrated. If n is decreased, MARK continues normally integrating the new n set of differential equations.

t_1 = single precision value of the independent variable in floating point.

t_2 = double precision value of the independent variable in floating point. This must be zero initially if P = 0 (single precision).

y_1 to y_N { values of the N differential equations for the dependent variables. The initial or starting values must be predetermined and set by the user (floating point).

y'_1 to y'_N { values of the derivatives of the dependent variables calculated and stored by the user's derivative routine (DER1, DER2). An initial pass is executed through DER1, DER2, and EOS by MARK before the integration process is commenced (floating point).

MARK entry points.- Provision is made through entry points to MARK to transmit certain information to MARK or to render certain information available to the user that is stored internally in MARK:

HC By using the command

```
CLA* $HC
```

the user has direct access to the current step size being used in the integration process. This is not necessarily the nominal step size, H, introduced by the user in the HBANK (floating point).

NI By using the command

```
STO* $NI
```

the user informs MARK that he desires i corrections to be performed on the predictor formula used in the Adams-Moulton fixed mode of integration. See Mathematical Description in this Appendix for description of the predictor-corrector formulas being used. In the automatic step size control mode i is automatically 1, and MARK ignores NI. Thus 1 correction is made for each prediction in this mode (fixed point).

TGLO — By using the command

```
CLA* $TGLO
```

The user has direct access to the most recent $t_{\eta+1}$ calculated, where $t_{\eta+1}$ represents the value of the independent variable at the end of an integration step (floating point).

Y — The command

```
CLA* $Y
```

gives the user access to the location of the dependent variables (single precision) in the HBANK. This appears as L(Y), where index register 1 set to n and counted down renders all the variables to the user (floating point).

YDOT — The command

```
CLA* $YDOT
```

Y(2) — performs the same function as Y for the derivatives of the dependent variables (floating point).

The command

```
CLA* $Y(2)
```

renders the location of the double precision part of the dependent variables available to the user (floating point).

YO

The commands

```
CLA* $YO
```

```
CLA* $YO(2)
```

render the locations of the single and double precision values of the dependent variables at t_η available to the user. Item t_η represents the value of the independent variable at the beginning of an integration step (floating point).

The following symbols refer to entry points used for the automatic step size mode.

EUBAR The command

```
STO* $EUBAR
```

stores $\overline{E}$ for use in automatic error control (floating point).

ELBAR The command

```
STO* $ELBAR
```

stores $\underline{E}$ in floating point for use with AEC.

HMAXT

```
STO* $HMAXT
```

stores maximum allowable H for AEC (automatic error control) (floating point).

HMINT

```
STO* $HMINT
```

stores minimum allowable H for AEC in floating point.

YCLOW

```
STO* $YCLOW
```

stores $\underline{Y}$ for AEC in floating point.

CLA* $RGERR

permits access to the maximum $E_{\eta} + 1$ for the user in floating point.

NOTE

EUBAR through YCLOW are consecutive locations in MARK.

Space required.- MARK requires $3453_8 = 1835_{10}$ storage locations. No COMMON is required. The user must supply

$$5N + 7 + 2N(m + 1)$$

storage locations for $\phi = 0,2$ or $7N + 7 + 3N(m + 2)$ for $\phi = 4$. N = maximum number of differential equations; m = order of differences to be carried in the Adams-Moulton mode. $\phi = 0,2$ is for Runge-Kutta integration or for Adams-Moulton integration in the fixed mode. Also, whatever storage is required for the user's derivative box and trigger control must be supplied.

Timing information.- MARK will do approximately 40 integration intervals per second. (This time was obtained from solving a set of 14 first-order differential equations.)

Checkout.- MARK has been checked out rather extensively using a variety of programs at the Jet Propulsion Laboratory. These programs include the JPL tracking program, a low thrust trajectory program, and a program of a general nature that solves a system of differential equations starting with five equations, repeating these five and adding sets of five with repetition until a maximum of thirty equations have been reached and integrated.

Mathematical Description

The classical Runge-Kutta fourth-order equations.- Let the system of equations to be solved be in the form,

$$y_j' = f_j(t, y_1 y_2, \ldots, y_n) \quad j = 1, 2, \ldots, N$$

Let $y_{j,\eta}$ be the value of y_j at $t = t_\eta$ and $f_{j,\eta}$ be the derivative of y_j at $t = t_\eta$. Let h be the step size of the independent variable t. Then,

$$K_1 = h\, f_j(t_\eta, y_{j,\eta})$$

$$K_2 = h\, f_j(t_\eta + 1/2\, h, y_{j,\eta} + K_1/2)$$

$$K_3 = h\, f_j(t_\eta + 1/2\, h, y_{j,\eta} + K_2/2)$$

$$K_4 = h\, f_j(t_\eta + \Delta t, y_{j,\eta} + K_3)$$

$$y_{j,\eta+1} = y_{j,\eta} + 1/6\,(K_1 + 2K_2 + 2K_3 + K_4)$$

The Adams-Moulton predictor-corrector equations.- Let y_j, y'_j be defined as above. Then,

$$Y^P_{j,\eta+1} = y_{j,\eta} + h(a_o\nabla^o + a_1\nabla^1 + \ldots + a_m\nabla^m)\, y'_j$$

(open type)

where ∇ is a backward difference operator operating on $y'_{j,\eta}$ and

$$\nabla^o y'_{j,\eta} = y'_{j,\eta}$$

The predictor coefficients a_m are:

$$a_o = 1.0$$

$$a_1 = 0.5$$

$$a_2 = 0.416666666$$

$$a_3 = 0.375$$

$$a_4 = 0.348611111$$

$$a_5 = 0.329861111$$

$$a_6 = 0.315591936$$

$$a_7 = 0.304224539$$

$$a_8 = 0.294868003$$

$$a_9 = 0.2870754484$$

$$y'^{P}_{j,\eta+1} = f_j(t_\eta, y_j) \quad j = 1,\ldots,N$$

$$y^{1}_{j,\eta+1} = y_{j,\eta} + h(b_o\nabla^o + b_1\nabla^1 + ,\ldots,+ b_m\nabla^m)\, y'^{P}_{j,\eta+1}$$

where Δ is defined as above, 1 is the first corrector application, and the corrector coefficients b_m are:

$$b_o = 1.0 \qquad b_5 = -0.01875$$

$$b_1 = -0.5 \qquad b_6 = -0.0142691795$$

$$b_2 = -0.0833333333 \qquad b_7 = -0.0113673950$$

$$b_3 = -0.0416666666 \qquad b_8 = -0.0093565362$$

$$b_4 = -0.0263888888 \qquad b_9 = -0.0078925542$$

NOTE

$$b_{m+1} = a_{m+1} - a_m$$

continuing

$$y^{2}_{j,\eta+1} = y_{j,\eta} + h(b_o\nabla^o + b_1\nabla^1 + \ldots + b_m\nabla^m)\, y'^{1}_{j,\eta+1}$$

$$y^{(i+1)}_{j,\eta+1} = y^{(i)}_{j,\eta+1} + h\,\sigma\,\epsilon^{(i)}$$

where

$$\sigma = \sum_{\ell = 0}^{m} b_m \quad ; \quad \epsilon^{(i)} = y'_{j,\eta + 1} \quad (i-1)$$

i is the i^{th} correction on the predictor formula.

The formula for interpolation to interrupt on a dependent variable in the Adams-Moulton mode.- The following formula applies:

$$q_j = (-)^q \left|\begin{matrix}\mu \\ j\end{matrix}\right| \text{ where } \mu = \frac{t_{\eta + 1} - t}{h_c} \geqslant 0$$

and

$$\left|\begin{matrix}\mu \\ j\end{matrix}\right| = \frac{(\mu-1)\,(\mu-2) \ldots (\mu-j)}{(j + 1)!} \qquad j = 1, \ldots, m$$

$$c_j = b_j + \sum_{i=0}^{j} q_i b_{j-i} \quad j=1, \ldots, m$$

b_j = corrector coefficients described in 2 above.

$$d_j = c_j^{\,j} \quad j = 1, \ldots, m$$

$$y_{\ell,\mu} = y_{\ell,\eta + 1} - h\mu \left(y'_{\ell,\eta + 1} + \sum_{j=1}^{m} d_j\right) \ell = 1, \ldots, n$$

Figure A-1 describes the configuration.

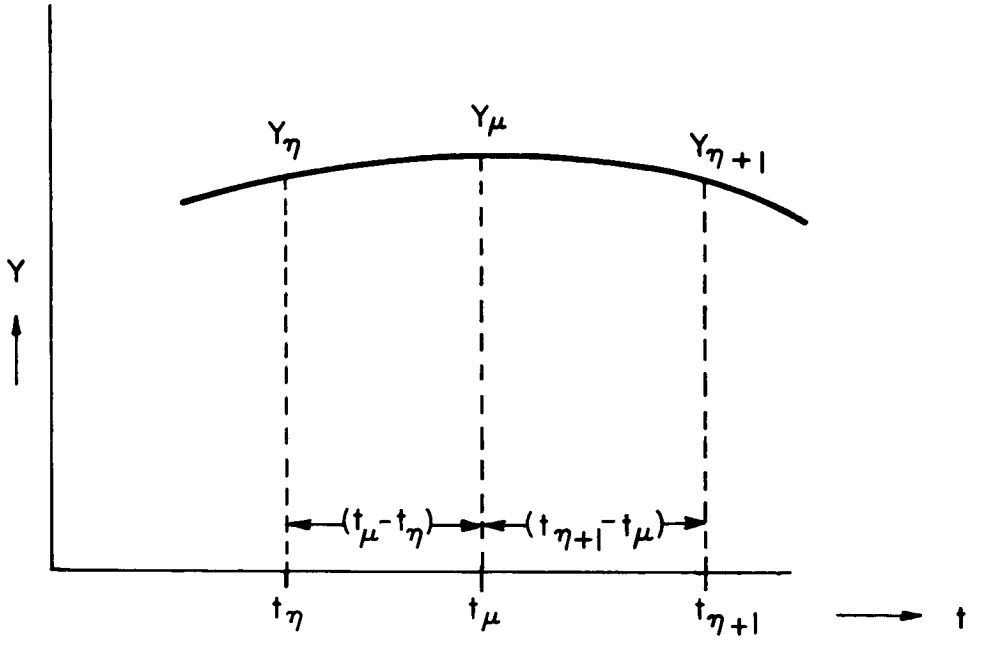

Figure A-1.- Plot of y versus t

The formula for interpolation to halve the step size (H), dropping the subscript j.- The following formula applies:

$$y'(\bar{t}) = \sum_{k=0}^{m} q_{-k}^{(m)}(\mu)\, y'(t_{\eta-k})$$

where

$$q_{-k}^{(m)}(\mu) = \frac{1}{m!} \prod_{i=1}^{m} (i + \mu)$$

$$\bar{t} = t_\eta - n\ell h \quad n = 1, 2, \ldots ; \ \ell = 1/2,\ 1/3, \ldots$$

$$\mu = \frac{t_\eta - n\ell h - t_\eta}{h} = -n\ell$$

Let $\ell = 1/2$, then $\mu = -1/2$ where n represents the absolute value of the subscript of $\bar{t}$ in Figure A-2.

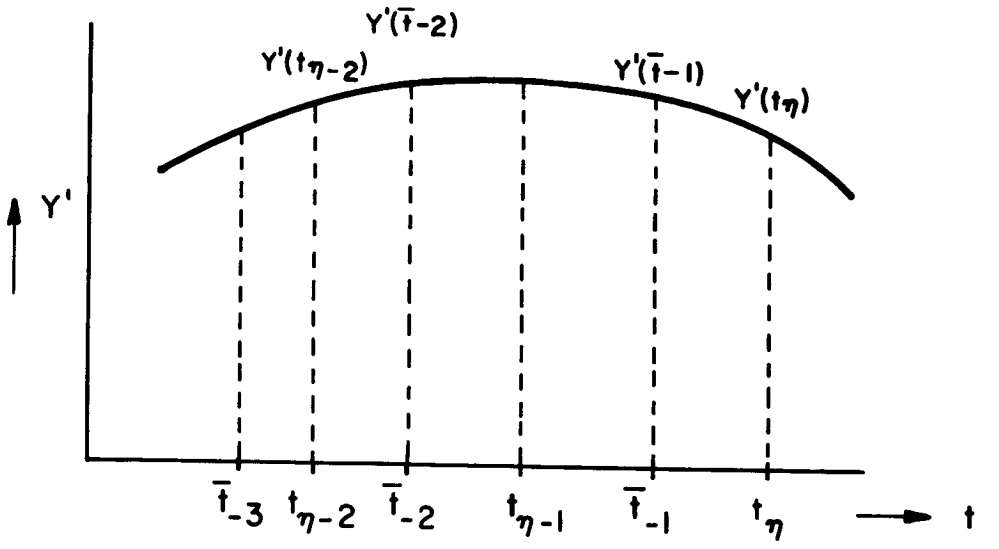

Figure A-2.- Plot of y' versus t

In the program:

$$q_o = \frac{1}{m!} \prod_{i=1}^{m} (i + \mu) \text{ and } q_{k+1} = q_k \frac{(\mu + k)(m - k)}{(\mu + k + 1)(k + 1)}$$

where k is the absolute value of the subscript of t in Figure A-2.

Automatic step-size control.- The following denotes automatic step-size control:

$$E_{\eta + 1} = \text{MAX} \frac{\left| y^P_{j,\eta + 1} - y^c_{j,\eta + 1} \right|}{A D_j}$$

where

$$A = \left| \frac{a_m}{b_{m+1}} \right| ; \quad D_j = \text{MAX} \left| y^c_{j,\eta + 1} \underline{y} \right|$$

The expression $E_{\eta + 1}$ represents the maximum error in any of the dependent variables in the final iterate $y_{j,\eta + 1}$ due to truncation error in the step from t_η to $t_{\eta + 1}$. The user, through the entry points, supplies MARK with a set of values to be described as follows:

(1) $\overline{E}$ - upper bound on the truncation error $E_{\eta + 1}$.

(2) $\underline{E}$ - lower bound on the truncation error $E_{\eta + 1}$.

(3) h_{max} - maximum allowable value of the step size.

(4) h_{min} - minimum allowable value of the step size.

(5) y - a constant used to prevent unnecessary reduction whenever $|y_{j,\eta + 1}|$ is small. $\underline{y} > 0$.

The step size, h, is doubled, left alone, or halved depending on the following inequalities:

(1) If $E_{\eta + 1} \leqslant \overline{E}$ for m successive steps, the step size, h, is set = 2h.

(2) If $\underline{E} < E_{\eta + 1} \leqslant \overline{E}$, the step size, h, is left alone.

(3) If $E_{\eta + 1} > \overline{E}$, the step size, h, is set = 1/2 h.

The program preserves all the conditions y_j, $\nabla_j^{m + 1}$ at t_η and integrates to $t_{\eta + 1}$.

If (1) holds, then MARK sets up the doubling procedure and integrates m + 1 more steps checking that (1) holds at each step. If (1) holds, the doubling procedure is completed and h = 2h.

If (2) holds, integration continues normally.

If (3) holds, then MARK restores $y_{j,\eta}$, $\nabla_{j,\eta}^{m + 1}$, t_η, $y'_{j,\eta}$. It executes the end of step box to restore those values at t_η. Finally, the halving procedure is executed and h = 1/2 h. Thus, it is never necessary on the basis of error control to restart the integration procedure in the Runge-Kutta mode. Item $\overline{E}$ is approximately equivalent to specifying the number of significant figures to preserve locally throughout the integration. Item $\overline{E}$ should normally range from 10^{-8} to 10^{-3}. $\underline{y}$ may be determined by the user but should probably range from 10^{-5} to 1.

```
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,      MAIN0003
     1              PMIN,     PRNT,     RELERR,   AO,       BO,        MAIN0004
     2              RO,       THETAO,   PHIO,     PLUS,     MPOWER,    MAIN0005
     3              NPLOT,    J,        NUAR,     N1,       FN,        MAIN0006
     4              DNDK,     DNDT,     DNDP,     EMU,      RTYSQR,    MAIN0007
     5              F,        F2,       C1,       FM,       COSPSI,    MAIN0008
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,    MAIN0009
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   EMUS,      MAIN0010
     8              N,        GNU,      MUFLAG,   NTEST                MAIN0011
      COMMON /HBANK1/ MORDER,     NOHALF,   NODOUB,   HBANK,    NOEQ,   MAIN0012
     1              FINVP,      FINVPI,   YO(11),   YD(11),   MA(260)MAIN0013
      COMMON /CKSR/ C,RCT,S,RST,Z,EM,IERM,TERM2,RMOD,RANG,Y06          MAIN0014
      COMMON /NEW/ PLOTO,RDOT                                          MAIN0017
      COMMON/EPSTN/EPSTIN,PROPT                                        MAIN0018
      COMMON /RSN/ IRSN
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,FIT,DNMNTR,DEL2S           MAIN0019
      COMMON /POWLOS/ COSA,     Y,        DMDR,     DMDT,     DMDP,    MAIN0020
     1              DMDY1,    DMDY2,    DMDY3,    DMDSI,    DMDDSI,    MAIN0021
     2              DMUDR,    DMUDT,    DMUDP,    DMUDY1,   DMUDY2,    MAIN0022
     3              DMUDY3,   DMUDSI,   EMU,      EMRAD                MAIN0023
      DIMENSION  DATE(04) ,   PLT(15)
      DIMENSION  DD(3002) ,  SOA(3002)
      COMMON / RECT  /     DD ,  SOA , LB
      COMMON / RDOTS /   JUMP , NYD1
C                                                                      MAIN0026
      COMMON /CONST / ORDER, EUBAR,ELBAR,YCLOW,HMAXT,HMINT,KD          MAIN0016
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
      COMMON /GRAPH0/  XMAX0 ,XMIN0 ,YMAX0 ,YMIN0 , PLT
C                                                                      MAIN0015
      DATA  PI  , PI02  / 3.1415927 , 1.5707963 /
      DATA  PI2 , RAD   / 6.2831853 , 0.0174533 /
  102 NTEST = 0                                                        MAIN0028
      J = 0
      N1=0                                                             MAIN0029
      NOEQ = 11                                                        MAIN0030
      KD=4                                                             MAIN0031
   39 CONTINUE
C
      NYD1  =  0
      IRSN  =  0
      LB    =  0
      ND    =  0
      N     =  0
C
  104 CALL INPUT                                                       MAIN0042
C                                                                      MAIN0041   12
      IF( IRSN .EQ. 1 ) GO TO 39
C
      PRNTO=PRNT                                                       MAIN0043
      PLOTT = PLOTO                                                    MAIN0044
      MORDER = ORDER                                                   MAIN0045
      TESTJ=HBANK                                                      MAIN0046
C
      DO 20 I1 = 1,10                                                  MAIN0048
   20 CALL ON(I1)                                                      MAIN0049   22
```

```
  105 CALL OFF(9)                                                    MAIN0050
C                                                                                27
      MUFLAG = 0                                                     MAIN0047
      FINVP=0.                                                       INPU0074
      FINVPI=0.                                                      INPU0075
      NUAR=10                                                        MAIN0051
      PROPT=1.                                                       MAIN0052
C
 1047 CALL SMARK(KD,NUAR,MORDER,NRTN,NTRG,EUBAR,ELBAR,HMAXT,HMINT,YCLOW,MAIN0053
     1FINVP,PRNTO,YO(1),PMAX,YO(1),RMIN,YO(2),TMAX,YO(2),TMIN,YO(3),PMAXMAIN0054
     1,YO(3),PMIN,FINVP,TESTJ,YD(1),ROOT,FINVP,PLOTT )               MAIN0055
C                                                                                32
  106 GO TO (40,41,41,42,43),NRIN                                    MAIN0056
C
   41 C=COS(YO(2))                                                   MAIN0057    35
      RCT=YO(1)*C                                                    MAIN0058
      S=SIN(YO(2))                                                   MAIN0059    36
      RST=YO(1)*S                                                    MAIN0060
      YSQUAR = 0.0
      DO 50  I = 4,6
      YADD  =  YO(I)
      YSQUAR = YSQUAR  + YADD * YADD
   50 CONTINUE
      RTYSQR  = SQRT( YSQUAR )
C                                                                                44
  107 CALL DENSE                                                     MAIN0063    46
      X   = EN / C1
      TERM = 1. - X
C
C     TEST IF VALUE OF TERM IS ABNORMAL
C
      IF( TERM ) 2000,2000,2001
 2000 WRITE(6,2002) TERM                                                         49
 2002 FORMAT(13H MAIN TERM = ,E15.5 )
      GO TO 4001
 2001 CONTINUE
C
  108 CONTINUE
      TERM2 = TERM * TERM
C
      CALL COLL( YO(1),YO(2),YO(3),GNU )
C                                                                                53
      Z = GNU/F * .15915494E-6                                       MAIN0069
  110 CALL FIELD                                                     MAIN0070
C                                                                                56
      Y     =  FH / F
      YT    =   Y * SINPSI
      YT2   =  YT * YT
      YL    =   Y * COSPSI
      YL2   =  YL * YL
      YLYT  =  YL * YT
C
      EM    =  0.5 * YT2 / TERM
      EMRAD =  PLUS * SQRT( EM* EM + YL2 )                                       58
      EMD   =  1. - EM + EMRAD
      EMUS  =  1. -  X / EMD
```

```
C
C     TEST IF VALUE OF EMUS IS ABNORMAL
C
      IF( EMUS ) 2003,2003,2004
 2003 WRITE(6,2005) EMUS                                          60
 2005 FORMAT(13H MAIN EMUS = ,E15.5 )
      GO TO 4001
 2004 CONTINUE
C
  116 EMU=SQRT(EMUS)                                    MAIN0082
C                                                                 64
  117 CALL FORCE                                        MAIN0083
C                                                                 66
  118 DMD=F2*TERM                                       MAIN0084
      DMN1=FH*SP2                                       MAIN0085
      DMN2=COSPSI*FH**2                                 MAIN0086
      DMT1=EM/12400.                                    MAIN0087
      DMT2=-DMN2/DMD                                    MAIN0088
      DMUN1=YL2/FH                                      MAIN0089
      DMUN2=YL2/COSPSI                                  MAIN0090
      DMD1=EMU/.5*EMD                                   MAIN0091
      DMUD1=C1*DMD1                                     MAIN0092
  119 DMUN3=X/DMD1/EMD                                  MAIN0093
C                                                       MAIN0094
C     COMPUTE DERIVATIVES OF M                          MAIN0095
C                                                       MAIN0096
  120 DMDR=(DMN1*DFHDR-DMN2*DCPDR+DMT1*DNDR)/DMD        MAIN0097
      DMDT=(DMN1*DFHDT-DMN2*DCPDT+DMT1*DNDT)/DMD        MAIN0098
      DMDP=(DMN1*DFHDP-DMN2*DCPDP+DMT1*DNDP)/DMD        MAIN0099
      DMDY1=DMT2*DCPDY1                                 MAIN0100
      DMDY2=DMT2*DCPDY2                                 MAIN0101
      DMDY3=DMT2*DCPDY3                                 MAIN0102
  121 DMDF=-YT2/F*1.E-6/TERM2                           MAIN0103
C                                                       MAIN0104
C     COMPUTE DERIVATIVES OF MU                         MAIN0105
C                                                       MAIN0106
  122 DMUDR=(EN*((EM*DMDR+DMUN1*DFHDR+DMUN2*DCPDR)/EMRAD  MAIN0107
     1-DMDR)/EMD-DNDR)/DMUD1                            MAIN0108
      DMUDT=(EN*((EM*DMDT+DMUN1*DFHDT+DMUN2*DCPDT)/EMRAD  MAIN0109
     1-DMDT)/EMD-DNDT)/DMUD1                            MAIN0110
      DMUDP=(EN*((EM*DMDP+DMUN1*DFHDP+DMUN2*DCPDP)/EMRAD  MAIN0111
     1-DMDP)/EMD-DNDP)/DMUD1                            MAIN0112
      DMUDY1=((EM*DMDY1+DMUN2*DCPDY1)/EMRAD-DMDY1)*DMUN3  MAIN0113
      DMUDY2=((EM*DMDY2+DMUN2*DCPDY2)/EMRAD-DMDY2)*DMUN3  MAIN0114
      DMUDY3=((EM*DMDY3+DMUN2*DCPDY3)/EMRAD-DMDY3)*DMUN3  MAIN0115
  123 DMUDF = (EMD/F * 2.E-6 - DMDF + (EM*DMDF -YL2/F * 1.F-6)/EMRAD)*  MAIN0116
     1        DMUN3                                       MAIN0117
C                                                       MAIN0118
C     COMPUTE KAPPA                                     MAIN0119
C                                                       MAIN0120
  124 EMZ = YT2/(TERM2 + Z**2)**.5                      MAIN0121
      A=EMZ*TERM                                        MAIN0122
      B=EMZ*Z                                           MAIN0123
      U=A**2-B**2+YL2                                   MAIN0124
      V = A/.5 * B                                      MAIN0125
      W = .5*(U + SQRT(U**2 + V**2))                    MAIN0126    74
```

```
      W = SQRT( ABS(W) )                                                MAIN0128   75
      A=1.-A*PLUS*W                                                     MAIN0129
      B=Z+B-PLUS/W*V/2.                                                 MAIN0130
  125 CAPPA=F/EMU*B/(A**2+B**2)*X/.095492                               MAIN0131
C                                                                       MAIN0132
C     COMPUTATION OF EPSTEIN CONDITION                                  MAIN0133
C                                                                       MAIN0134
  126 EPSTIN=B*X/(A**2+B**2-A*X)                                        MAIN0135
C                                                                       MAIN0136
C     COMPUTE COS(ALPHA)                                                MAIN0137
C                                                                       MAIN0138
  127 DMDSI=YLYT/TERM                                                   MAIN0139
      DMDDSI=(EM*DMDSI-YLYT)/EMRAD=DMDSI                                MAIN0140
      DMUDSI=DMDDSI*DMUNX                                               MAIN0141
  128 COSA=EMU/SQRT(EMUS+DMUDSI**2)                                     MAIN0142
C                                                                       MAIN0143
C     COMPUTE DERIVATIVES OF RAY COORDINATES                            MAIN0144
C                                                                       MAIN0145   80
  129 YD(1)=(YO(4)-EMU*DMUDY1)/EMUS                                     MAIN0146
      YD(2)=(YO(5)-EMU*DMUDY2)/EMUS/YO(1)                               MAIN0147
      YD(3) = (YO(6)  - EMU*DMUDY3)/EMUS/RST                            MAIN0148
      YD(4) = DMUDR/EMU + YD(2)*YO(5) + YD(3)*YO(6)*S                   MAIN0149
      YD(5)  = (DMUDT/EMU - YD(1)*YD(5) + YD(3)*YO(6)*RCT)/YO(1)        MAIN0150
      YD(6) = (DMUDP/EMU - YO(6)*(YD(1)*S+YD(2)*RCT))/RST               MAIN0151
      YD(7)=1.+E*1.E6/EMU*DMUDE                                         MAIN0152
      YD(8)=1./EMU/COSA                                                 MAIN0153
      YD(9)=-CAPPA/EMU*YO(9)                                            MAIN0154
C                                                                       MAIN0155
C      TO COMPUTE THE DOPPLER SHIFT USING JONES METHOD                  MAIN0156
C                                                                       MAIN0157
  130  YD(10)=DMUDP/EMU                                                 MAIN0158
  131 IF(NPOWER.NE.0) CALL POWERL                                       MAIN0159   85
   40 CALL TRA14                                                        MAIN0160
C
C                                                                                  88
   42 IF (NTRG .EQ. 3 .AND. J .EQ. 2 ) NTRG = 11                       MAIN0163
  132 CALL OUTPUT(NTRG)                                                 MAIN0164   93
  133 GO TO (44,39,39,39,39,39,45,908,47,46 ) , NTRG                    MAIN0165
   44 PRNTO=PRNTO+PRNT                                                  MAIN0166
      CALL TRA14
C
C                                                                                  96
  908 IF (NYD1 - 2 )4000,4001,4001
 4001 CALL OUTPUT(1)                                                              100
      JUMP = 2
      CALL OUTPUT(10)                                                             103
      GO TO 39
 4000 CALL TRA14
C
C                                                                                  106
   47 PLOTT = PLOTT + PLOTO                                             MAIN0168
      CALL TRA14                                                        MAIN0169
C
C                                                                                  108
   45 CALL ON(3)                                                        MAIN0170   110
  134 CALL OFF(8)                                                       MAIN0171   112
```

```
  135 CALL ON(9)                                                        MAIN0172   114
  136 IF(NPOWER.EQ.1.AND.NUAR.EQ.10) GO TO 1046                         MAIN0173
      CALL TRA14                                                        MAIN0174
C
C      COMPUTE POWER LOSS IN NEAR FIELD
C
 1046 NUAR=11                                                                    118
      HBANK=.001                                                        MAIN0175
      THETA=THETAD*RAD                                                  MAIN0176
  137 EMUPI=EMUINT*PI                                                   MAIN0177
C                                                                       MAIN0178
      CALL CSINT(EMUPI,CIMUPI,SIMUPI)                                             122
      CALL CSINT(EMUINT*2.,CIM2PI,SIM2PI)
C                                                                                 124
  140 EMUPI2=EMUINT*PI02                                                MAIN0181
      DENOM=.5772+ALOG(EMUPI)-CIMUPI+SIN(EMUPI)/2.*(SIM2PI-2.*SIMUPI)   MAIN0182
     1  +COS(EMUPI)/2.*(.5772+ALOG(EMUPI2)+CIM2PI-2.*CIMUPI)             MAIN0183   126  127  128  129
      COSPSI=SIN(THETA)*SIN(YO(2))*COS(PHI0*RAD-YO(3))                  MAIN0184
     1  +COS(THETA)*COS(YO(2))                                          MAIN0185   130  131  132  133  134
      RO2=RO**2                                                         MAIN0186
      R2=YO(1)**2                                                       MAIN0187
      RP2=R2+RO2-2.*RO*YO(1)*COSPSI                                     MAIN0188
      RP=SQRT(RP2)                                                      MAIN0189   135
      PSI=PI-ARCOS((RP2+RO2-R2)/(2.*RP*RO))                             MAIN0190   136
  141 PROPT=((COS(EMUPI2*COS(PSI))-COS(EMUPI2))/SIN(PSI))**2            MAIN0191
     1  /(PI2*RP2*DENOM)*.7161972E-2/F2/EMUINT                          MAIN0192   138  139  140  141
      GO TO 1047                                                        MAIN0193
C
C
   46 YO(4) = -YO(4)                                                    MAIN0194
  142 YO(10) = 0.                                                       MAIN0195
  143 CALL OFF(3)                                                       MAIN0196   146
  144 CALL ON(8)                                                        MAIN0197   148
  145 TEST3 = PRNTO + PRNT                                              MAIN0198
  146 CALL TRA24                                                        MAIN0199
C
C
   43 WRITE(6,1000)                                                                 151
      STOP                                                              MAIN0200   152
 1000 FORMAT(24H1 ERROR RETURN FROM MARK)                               MAIN0202
      END                                                               MAIN0203
```

INPU - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE INPUT
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,        INPU0003
     1              PMIN,     PRNT,   RELERR,       AO,       BO,        INPU0004
     2                RO,   THETAO,     PHIO,    PLUS,   NPOWER,        INPU0005
     3             NPLOT,        J,     NUAR,       N1,       FN,        INPU0006
     4              DNDR,     DNDI,     DNDP,      EMU,   RTYSQR,        INPU0007
     5                F,       F2,       C1,       FH,   COSPSI,        INPU0008
     6            SINPSI,   DFHDR,    DFHDI,    DCPDI,   DCPDY1,        INPU0009
     7            DCPDY2,   DCPDY3,     SP2,   EMUINT,     EMUS,        INPU0010
     8                N,      GNU,   MUFLAG                              INPU0011
      COMMON  /HBANK1/ MORDER,     NOHALF,     NODOUB,    HBANK,    NOEQ,  INPU0012
     1               FINVP,      FINVPI,     YO(11),    YD(11),   MA(260)INPU0013
      COMMON /CRSR/ CR,RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RARG,Y06             INPU0017
      COMMON /CONST / ORDER, EUBAR,ELBAR,YCLOW,HMAXI,HMINI,KD              INPU0018
      COMMON /NEW/ PLOTO,RDOT
       COMMON/RECT/UD(3002),SOA(3002), LR
      COMMON /RSN/ IRSN
      COMMON / KBLK1 /  STEMS , HPRIME , PRDELN , AMBDL , H0
C
C
      COMMON /GRAPH0/  XMAX0 ,XMIN0 ,YMAX0 ,YMIN0 , PLT
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
      COMMON /GRAPH2/  TITLE
C
C
      DIMENSION  V(3) ,W(3)
      DATA  V / 0.9788 , 0.0196 , 0.0016 /
      DATA  W / 66.546 , 265.98 , 1056.3 /
C
      DIMENSION TITLE(20)
      DIMENSION PLT(15) , DATE(4)
      DIMENSION D( 50)
C
      NAMELIST / XNAME5 /  XMAX0 , XMIN0 , YMAX0 , YMIN0 ,
     1                     XMAX1 , XMIN1 , YMAX1 , YMIN1
      NAMELIST / XNAME3 /  ORDER , EUBAR , ELBAR ,
     1                     YCLOW , HMAXI , HMINI , KD
      NAMELIST / XNAME1 /      J ,  LAST ,NTITLE ,NCONST , LIMITS
C
C     FORMAT STATEMENTS
C
  781 FORMAT(8F10.3)
  981 FORMAT(10X,8F10.4)
  500 FORMAT(20A4)
  501 FORMAT(4012)
  999 FORMAT(  1H1 , 20X , 20A4 )
 1000 FORMAT(  // 20X , 30H1NITIAL RAY POSITION            ,
     1           10X , 30H1NITIAL RAY DIRECTION            ,
     2         // 20X ,  7HRO       , F10.2 , 23X , 7HAO       , F6.2 ,
     3          / 20X ,  7H1HETAO   , F10.2 , 23X , 7HRO       , F6.2 ,
     4          / 20X ,  7HPHIO     , F10.2 , 23X , 7HDELAO    , F6.2   )
 1001 FORMAT(  // 20X , 30HRAY CHARACTERISTICS            ,
     1           10X , 30HFIELD LINE                       ,
     2         // 20X ,  7HFREQ     , F5.2 ,  27X , 7HLAMBDA   , F7.2 ,
     3          / 20X ,  7HMODE     ,  I2  ,  30X , 7HL-VALUE  , F7.2   )
```

```
INPU      - EFN   SOURCE STATEMENT  - IFN(S) -
 1002 FORMAT(  // 30X , 30HSTOP CONDITIONS                    ,
     1             30HINTERVALS                               ,
     2           / 30X , 15H MAX       MIN    ,
     3           / 20X ,  7HRADIUS    , 2F9.1 , 15X ,  7HPRINT  , F6.1 ,
     4           / 20X ,  7HTHETA     , 2F9.1 , 15X ,  7HPLOT   , F6.1 ,
     5           / 20X ,  7HPHI       , 2F9.1 , 15X ,  7HSTEP   , F6.1   )
 1003 FORMAT(  // 20X , 30HPROGRAM OPTIONS                    ,
     1             10X , 30HOTHER INITIAL VALUES              ,
     2           // 20X ,  7HNPOWER  , I1 , 32X , 12HSCALE SIZE  , F7.3 ,
     3           / 20X ,  7HNPLOT   , I1 , 32X , 12HPKFRAC     , F7.3 ,
     4           / 20X ,  7HNOVER   , I1 , 32X , 12HPRIME      , F7.3 ,
     5           / 20X ,  7HNAUTO   , I1 , 32X , 12HPKDELN     , F7.3 ,
     6           / 20X ,  7HJTEST   , I1       )
C                                                              INPU0025
      RAD=.01745329
      RPERD = 0.01745329
      RDOI = 0.
      REARTH = 6378.0
C                                                              INPU0021
      IF( LAST .GT. 0 ) GO TO 11
      READ( 5,XNAME1 )                                                  4
      IF( NTITLE .GT. 0 ) READ( 5,500 ) TITLE                           6
      IF( NCONST .GT. 0 ) READ( 5,XNAME3 )                              9
      IF( LIMITS .GT. 0 ) READ( 5,XNAME5 )
C
C
C                                                                      11
      RO      =  D(01)
      THETAO  =  D(02)
      PHIO    =  D(03)
      AO      =  D(04)
      BO      =  D(05)
      DELAO   =  D(06)
C
C     LOAD MAX AND MIN VALUES OF R, THETA AND PHI
C
      RMAX  =  D(07)
      RMIN  =  D(08)
      TMAX  =  D(09) * RPERD
      TMIN  =  D(10) * RPERD
      PMAX  =  D(11) * RPERD
      PMIN  =  D(12) * RPERD
C
      PRINT  =  D(13)
      PRNT   =  PRINT
      PLINT  =  D(14)
      PLOTO  =  PLINT
      HBANK  =  D(15)
C
      F    = D(16)
      MODE = D(17)
      PLUS   = MODE
      JTEST  = D(18)
      J      = JTEST
C
      NPOWER = D(19)
```

```
      NPLOT  = D(20)
      NOVER  = D(21)
      NAUTO  = D(22)
C
      H0     = D(23)
      PKFRAC = D(24)
      AMBDL  = D(25)
C
C     CALCULATE  R0
C
      AMBDA  = AMBDL * RPERD
      TH0    = THETA0 * RPERD
C
      SNLAM1 = SIN( AMBDA )                                          21
      SNLAM2 = SNLAM1 * SNLAM1
      SNLAM3 = SNLAM2 * SNLAM1
C
      SNTH01 = SIN( TH0 )                                            22
      SNTH02 = SNTH01 * SNTH01
      SNTH03 = SNTH02 * SNTH01
C
      TNTH01 = TAN( TH0 )                                            23
      TNTH02 = TNTH01 * TNTH01
C
      STSL   =  SNTH01 / SNLAM1
      ZM1 =  SQRT ( 4.0 - 3.0 * SNTH02 )                             24
      ZM2 =  SQRT ( 4.0 - 3.0 * SNLAM2 )                             25
      ZM3 =  ZM2 * SNTH03
      ZM4 =  ZM1 * SNLAM3
      ZM5 =  ZM3 / ZM4
C
      H = H0 * ZM5
      HPRIME =  .707 * H
      HPRIM1 =  SQRT ( 1.0 + 4.0/  TNTH02 )
C                                                                    26
      STZM5  = ZM5
      IF( NAUTO .LE. 0 ) GO TO 60
      R0  =  REARTH * STSL * STSL  -  HPRIME * HPRIM1
      D(01) = R0
   60 CONTINUE
C
C
C     CALCULATE  A0
C
      WALSH1  =  0.5 * TAN( TH0 )                                    31
      WALSH2  =  ATAN( WALSH1 )                                      32
      WALSH3  =  WALSH2 / RPERD
      A0      =  WALSH3 + DELA0
      D(04)   =  A0
C
C     CALCULATE ELECTRON DENSITY AT R0,THETA0,PHI0
C
      W1  = ( R0 - 6728. ) / 50.
      T17 = 0.5 * ( 1.0 - W1 - EXP(-W1) )                            33
      ENF = 2.7E5 * EXP( T17 )                                       34
      ZX  = 6878.0 *( 1. - 6878./ R0 )
```

```
C
C
      ENXR   = 0.0
      DO 100 I = 1,3
  100 ENXR = ENXR + V(I) * EXP( -ZX / W(I) )                          40
      ENXR =          SQRT( ENXR )                                    44
      ENXR  = 4.0 * ENXR
C
C
      ENX  = ENXR * ( 1.659E3 * ABS( RHO - 1.5707963 ) + 16620. )
      IF( RO - 7378. ) 40,41,41
   40 TM  =(RO - 7378.)/ 500.
      FACTOR = EXP( - TM*TM )                                         47
      ENX  = ENX * FACTOR
   41 EN = ENX + ENF
      PKDELN = PKFRAC * EN
C
C     LOAD PLOTTING TITLE INFORMATION
C
      PLT(01)  =  RO
      PLT(02)  =  THETAO
      PLT(03)  =  PHIO
      PLT(04)  =  AO
      PLT(05)  =  BO
      PLT(06)  =  DELAO
      PLT(07)  =  AMBDL
      PLT(08)  =  PKFRAC
      PLT(09)  =  HPRIME
      PLT(10)  =  HO
      PLT(11)  =  H1
      PLT(12)  =  F
      PLT(13)  =  MODE
C
C
C
C
      A  =  AO * RPERD
      B  =  BO * RPERD
C
      YO(01)  =  RO
      YO(02)  =  THETAO * RPERD
      YO(03)  =  PHIO   * RPERD
      YO(04)  =  COS(A)                                               49
      YO(06)  =  SIN(A) * SIN(B)                                      50    51
      YO(05)  =  SIN(A) * COS(B)
C                                                                     52    53
      F2 =       F * F
      C1 =  1.24E4 * F2
C
  112 CALL DENSE                                          INPU0084
C                                                                     55
      X    = EN / C1
      TERM = 1. - X
C
C     TEST IF VALUE OF TERM IS ABNORMAL
C
```

```
      IF( TERM ) 2000,2002,2001
 2000 IRSN = 1
      WRITE(6,2002) TERM                                              59
 2002 FORMAT( 14H INPUT TERM = ,F15.5)
      RETURN
 2001 CONTINUE
C
      TERM2 = TERM * TERM
      C     = COS( THO )                                              61
      S     = SIN( THO )
C                                                                     62
      Y042 = Y0(4) * Y0(4)
      Y052 = Y0(5) * Y0(5)
      Y062 = Y0(6) * Y0(6)
      YSQUAR= Y042 + Y052 + Y062
      RTYSQR  = SQRT( YSQUAR )
C                                                                     63
  115 CALL FIELD                                          INPU0091
C                                                                     65
      Y       =  FM / F
      YT      =   Y * SINPSI
      YT2     =  YT * YT
      YL      =   Y * COSPSI
      YL2     =  YL * YL
      YLYT    =  YL * YT
      EM      =  0.5 * YT2 / TERM
      EMRAD =  PLUS * SQRT( EM* EM + YL2 )                            67
      EMD     =  1. - EM + EMRAD
      EMUS    =  1. -  X / EMD
C
C     TEST IF VALUE OF EMUS IS ABNORMAL
C
      IF( EMUS ) 2003,2003,2004
 2003 IRSN = 1
      WRITE(6,2005) EMUS                                              70
 2005 FORMAT( 14H INPUT EMUS = , E15.5)
      RETURN
 2004 CONTINUE
      EMUZ  =  SQRT( EMUS)                                            72
      EMUINT  =  EMUZ
C
C
      Y0(04)  =  Y0(04) * EMUZ
      Y0(05)  =  Y0(05) * EMUZ
      Y0(06)  =  Y0(06) * EMUZ
      Y0(07)  =  0.0
      Y0(08)  =  0.0
      Y0(09)  =  1.0
      Y0(10)  =  0.0
      Y0(11)  =  0.0
      NUAR    =  10
C
C
C     TEST PROGRAM OPTION INDICATORS
C
      IF( MPLOT .LE. 0 ) GO TO 9
```

```
      IF( NOVER ) 62,62,63                                                    79
   62 CALL CALC01
      GO TO 9
   63 CALL CALC03                                                             82
                                                              MAIN0027
    9 CONTINUE
      EL    = 1.0 / SNLAM2
C
      WRITE(6, 999)  TITLE                                                    84
      WRITE(6,1000)  RO , AO , THETAO , BO , PHIO , DELAO                     86
      WRITE(6,1001)      F,  AMBDL,   MODE,      EL                           87
      WRITE(6,1002)  D(7) , D(8) , D(13) ,
     1               D(9) , D(10), D(14) ,
     2               D(11), D(12), D(15)                                      88
      WRITE(6,1003)  NPOWER,      M0,  NPLOT, PKFRAC,
     1                NOVER, MPRIME,  NAUTO, PKDELN, JTEST                    89
      RETURN                                                  INPU0117
C
   11 IF( NPLOT .GT. 0 )  CALL CALC02                                         92
      STOP
      END
```

```
$IBFTC OUTPU   LIST,REF
```

```
      SUBROUTINE OUTPUT(IFLAG)                                          OUTP0002
      COMMON/EPSTN/EPSTN,PROPT                                          OUTP0006
      COMMON /DATA/ RMAX,     PMIN,     TMAX,     TMIN,     PMAX,     OUTP0007
     1              PMIN,     PRN1,   RELERR,       A0,       B0,     OUTP0008
     2                R0,   THETA0,     PHI0,    PLUS,   MPOWER,     OUTP0009
     3             NPLOT,        J,     NOAR,      N1,       FN,     OUTP0010
     4              DNDR,     DNDT,     DNDP,     EMU,   RTYSQR,     OUTP0011
     5                 F,       F2,       C1,      FH,   COSPSI,     OUTP0012
     6            SINPSI,   DFHDR,    DFHDT,   DCPDT,   DCPDY1,     OUTP0013
     7            DCPDY2,   DCPDY3,      SP2,  FMUINT,     FMUS,     OUTP0014
     8                 N,      GNU,   MUFLAG                          OUTP0015
      COMMON  /HBANK1/ MORDER,     NORMALF,   NODOUB,   HBANK,    NOEQ, OUTP0016
     1                 FINVP,     FINVPI,    Y0(11),   YD(11),   MA(260)OUTP0017
      COMMON /CHSR/ C,RCT,S,RST,Z,FM,TERM,TERM2,RMOD,RARG,Y06           OUTP0018
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,F1T,DNMNTR,DEL2S            OUTP0019
      COMMON /POWLOS/  CPSA,       Y,     DMDR,     DMDT,     DMDP,     OUTP0020
     1                 DMDY1,    DMDY2,    DMDY3,    DMDSI,   DMUDSI,  OUTP0021
     2                 DMUDR,    DMUDT,    DMUDP,   DMUDY1,  DMUDY2,   OUTP0022
     3              DMUDY3,   DMUDSI,      EMU,      EMRAD              OUTP0023
C
C
      DIMENSION XX(502),YY(502)
      DIMENSION  DATE(04) ,   PLT(15)
      DIMENSION TITLE(20)
C
      COMMON /GRAPH2/  TITLE
      COMMON / RECT  /    DD ,  SDA , LB
      COMMON / RDOTS /  JUMP , NYD1
C
C
      THETA=57.2957795*Y0(2)                                            OUTP0024
      PHI=57.2957795*Y0(3)                                              OUTP0025
C
  200 DSHIFT=-2.424067E-6*F*Y0(10)                                      OUTP0026
  201 VALCRT=SQRT(DMUDR*DMUDR+(DMUDT/Y0(1))**2+(DMUDP/RCT)**2)          OUTP0027
     1      /(20.943933*F*EMUS)                                        OUTP0028
C
      IF(JUMP .EQ. 2 ) GO TO 101
  202 JUMP = 1                                                          OUTP0029
  203 IF (IFLAG .NE. 10 ) GO TO 100                                     OUTP0030
  204 IF(N .EQ. 0) RETURN
C
  101 LL=LL+1                                                           OUTP0032
      XX(LL)=Y0(1)                                                      OUTP0033
      YY(LL)=THETA                                                      OUTP0034
  206 IF (LL .EQ. 500) GO TO 46                                         OUTP0037
      GO TO (29,46) , JUMP                                              OUTP0038
  100 IF(N.NE.0) GO TO 27                                               OUTP0040
C
  207 C2=4.2473703E-6/F                                                 OUTP0041
      LL=1                                                              OUTP0042
      XX(1)=R0                                                          OUTP0043
      YY(1)=THETA0                                                      OUTP0044
      GO TO 209
C
```

```
   26 IF(N.NE.13) GO TO 27                                          OUTP0047
  209 WRITE(6,1007) TITLE
   28 WRITE(6,1002)                                                 OUTP0049
  210 N = 1                                                         OUTP0050
   27 YOSQR = Y0(4)**2 + Y0(5)**2 + Y0(6)**2                        OUTP0052
C                                                                   OUTP0053
C     GROUP DELAY IN MILLISECONDS                                   OUTP0054
C                                                                   OUTP0055
  211 GROUEL=Y0(7)/3.0E2                                            OUTP0056
C
  212 CALL POLAR
      PARG = PARG*57.2957795                                        OUTP0057
C                                                                   OUTP0058
  213 IF(NPOWER.NE.0) GO TO 21                                      OUTP0059
  214 PL=0.0                                                        OUTP0060
      DELPS=0.0
      GO TO 22                                                      OUTP0062
   21 PL=10.*ALOG10(EMU*PROPT*EXP(-Y0(11)))                         OUTP0063
C
C
   22 WRITE(6,1003) FINVP,Y0(1),THETA,PHI,Y0(3),DSHIFT,PL,          OUTP0064
     1              Y0(7),Y0(4),Y0(5),Y0(6),EMIS,YOSQR,EPSTIN,      OUTP0065
     2              Y0(8),RMOD,PARG,VALCPT,EN,GNU,GROUEL            OUTP0066
  215 N = N + 1                                                     OUTP0067
C
C
  216 GO TO (29,40,41,42,43,44,45,29,47,29,29 ) , JFLAG             OUTP0068
C
   40 WRITE(6,2040)                                                 OUTP0069
      GO TO 217                                                     OUTP0071
   41 WRITE(6,2041)                                                 OUTP0072
      GO TO 217                                                     OUTP0074
   42 WRITE(6,2042)                                                 OUTP0075
      GO TO 217                                                     OUTP0077
   43 WRITE(6,2043)                                                 OUTP0078
      GO TO 217                                                     OUTP0080
   44 WRITE(6,2044)                                                 OUTP0081
      GO TO 217
   45 WRITE(6,2045)                                                 OUTP0087
  217 JUMP = 2                                                      OUTP0092
      GO TO 101                                                     OUTP0093
C
   47 WRITE (6,2046) YD(1)                                          OUTP0095
      IF (ABS(THETA - 90. ) .LT. 2.0 ) GO TO 101
      NYD1 = NYD1 + 1
      GO TO 101

   46 IF( NPLOT .LO. 0 ) RETURN
      CALL CALC04( LB , YD , SOA )
      CALL CALC05( LL , YA , YY  )

      RESET COUNTERS

      JUMP =  1
      LL   =  0
      LB   =  0
```

```
C
   29 RETURN
C
C     FORMAT STATEMENTS
C
 2040 FORMAT(25H0STOPPED ON TEST FOR RMAX)                                  OUTP0098
 2041 FORMAT(25H0STOPPED ON TEST FOR RMIN)                                  OUTP0099
 2042 FORMAT(30H0STOPPED ON TEST FOR THETA MAX)                             OUTP0100
 2043 FORMAT(30H0STOPPED ON TEST FOR THETA MIN)                             OUTP0101
 2044 FORMAT(28H0STOPPED ON TEST FOR PHI MAX)                               OUTP0102
 2045 FORMAT(28H0STOPPED ON TEST FOR PHI MIN)                               OUTP0103
 2046 FORMAT (9HORDOT =   E15.6 )                                           OUTP0104
 1002 FORMAT(10X10HPHASE PATH6X6HRADIUS10X10HCOLATITUDE6X9HLONGITUDE7X10OUTP0105
     1HABSORPTION6X10HDOPPLER SP6X10HPOWER LOSS/10X10HGROUP PATH6X2HY114OUTP0106
     2X2HY214X2HY314X5HM1**211X4HY**212X10HEPSTEIN CD/10X8HRAY PATH8X26HOUTP0107
     3POLARIZATION - MOD AND ARG6X6HDEL MU10X1HN15X2HNU14X              OUTP0108
     411HGROUP DELAY)                                                   OUTP0109
 1003 FORMAT(/6X1P7E16.7/(6X7E16.7))                                    OUTP0110
 1007 FORMAT( 1H1 , 20X , 20A4 )                                        OUTP0111
      END                                                               OUTP0112
```

$1BFTC SC

```
      BLOCK DATA
      COMMON /GRAPH0/ XMAX0 ,XMIN0 ,YMAX0 ,YMIN0 , PLT
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
      COMMON /CONST / ORDER, EUBAR,ELBAR,YCLOW,HMAXT,HMINT,KD          MAIN0016
C
C     NOMINAL PLOT LIMITS
C
      DATA  YMIN0 , YMAX0  / 0.0E0 , 1.2E4 /
      DATA  XMIN0 , XMAX0  /-1.8E1 , 2.0E0 /
      DATA  XMIN1 , XMAX1  / 0.0E0 , 2.0E4 /
      DATA  YMIN1 , YMAX1  / 0.0E0 , 1.0E4 /
C
C     NOMINAL INTEGRATION PARAMETERS
C
      DATA  ORDER , EUBAR , ELBAR / 1.0E 0 , 1.0E-5 , 1.0E-7 /
      DATA  YCLOW , HMAXT , HMINT / 1.0E-7 , 1.0E 4 , 1.0E-7 /
C
      END
```

$IBFTC SCA

```
      SUBROUTINE PRAM(X,Y,LL,XMIN,YMIN,XMAX,YMAX,XLEN,YLEN)
      DIMENSION X(1),Y(1)
C
      X( LL + 1 ) = XMIN
      Y( LL + 1 ) = YMIN
C
      X( LL + 2 ) = ( XMAX - XMIN ) / XLEN
      Y( LL + 2 ) = ( YMAX - YMIN ) / YLEN
      RETURN
      END
```

SIBEIC CALCO

```
      SUBROUTINE CALCO4(LL,X,Y)
C
      COMMON /GRAPH0/  XMAX0 ,XMIN0 ,YMAX0 ,YMIN0,PLT
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
C
      DIMENSION PLDAT(360) ,  X(3002) , Y(3002)
      DIMENSION    PLT(15) ,  DATE(5)
C
      MODE = PLT(13)
C
      CALL  PRAM(X,Y,LL,XMIN0,YMIN0,XMAX0,YMAX0,10.,12.)
C                                                                     3
      IF( LVAL .NE. 1 ) GO TO 12
      CALL AXIS(0.0,0.0,21HDIS FROM FLD LN IN KM,21,10.,90.0, X(LL+1),
     1 X(LL+2))                                                      10
      CALL AXIS(0.0,0.0,24HDIS ALONG FLD LN IN KM          ,-24,12.0,
     10.0, Y(LL+1), Y(LL+2))
C                                                                    14
      CALL SYMBOL (1.0,9.6,0.10,8HRO    = ,0.0,8)                  16
      CALL NUMBER (2.0,9.6,0.1, PLT(01) , 0.0 , 2 )                18
      CALL SYMBOL (4.0,9.6,0.10,8HAO     =,0.0,8)                  20
      CALL NUMBER (5.0,9.6,0.1, PLT(04) , 0.0 , 3 )                22
      CALL SYMBOL (7.0,9.6,0.10,8HDELAO  =,0.0,8)                  24
      CALL NUMBER (8.0,9.6,0.1, PLT(06) , 0.0 , 3 )                26
      CALL SYMBOL (1.0,9.2,0.10,8HTHETA  =,0.0,8)                  28
      CALL NUMBER (2.0,9.2,0.1, PLT(02) , 0.0 , 3 )                30
      CALL SYMBOL (4.0,9.2,0.10,8HRO     =,0.0,8)                  32
      CALL NUMBER (5.0,9.2,0.1, PLT(05) , 0.0 , 2 )                34
      CALL SYMBOL (7.0,9.2,0.10,8HHPRIME =,0.0,8)                  36
      CALL NUMBER (8.0,9.2,0.1, PLT(09) , 0.0 , 3 )                38
      CALL SYMBOL (1.0,8.8,0.10,8HPHI    =,0.0,8)                  40
      CALL NUMBER (2.0,8.8,0.1, PLT(03) , 0.0 , 3 )                42
      CALL SYMBOL (4.0,8.8,0.10,8HPKFRAC =,0.0,8)                  44
      CALL NUMBER (5.0,8.8,0.1, PLT(08) , 0.0 , 3 )                46
      CALL SYMBOL (1.0,8.4,0.10,8HLAMBDA =,0.0,8)                  48
      CALL NUMBER (2.0,8.4,0.1, PLT(07) , 0.0 , 3 )                50
      CALL SYMBOL (4.0,8.4,0.10,8HH0     =,0.0,8)                  52
      CALL NUMBER (5.0,8.4,0.1, PLT(10) , 0.0 , 3 )                54
      CALL SYMBOL (1.0,8.0,0.10,8HFREW   =,0.0,8)                  56
      CALL NUMBER (2.0,8.0,0.1, PLT(12) , 0.0 , 3 )                58
      CALL SYMBOL (4.0,8.0,0.10,8HH1     =,0.0,8)                  60
      CALL NUMBER (5.0,8.0,0.1, PLT(11) , 0.0 , 3 )
C                                                                    62
      IF(MODE) 10,12,11
   10 CALL SYMBOL (7.0,8.8,0.1,18HEXTRAORDINARY MODE,0.0,18)       66
      GO TO 12
   11 CALL SYMBOL (7.0,8.8,0.1,13HORDINARY MODE,0.0,13)            69
   12 CALL LINE(Y,X,LL,KVAL,JVAL,LVAL)                             71
      RETURN
C
      ENTRY CALCO5(LL,X,Y)
C
      CALL PLOT(17.5,5.,-3)                                        74
      DO 600 II=1,LL
      AR=X(II)
```

```
      Y(II)=Y(II)*3.141593/180.
      X(II)=AR*SIN(Y(II))                                          83
  600 Y(II)=AR*COS(Y(II))
C                                                                  87
      CALL PRAM(X,Y,LL,XMIN1,YMIN1,XMAX1,YMAX1,10.,5.)             91
      CALL LINE(X,Y,LL,KVAL,JVAL,LVAL)
C                                                                  93
      IF(LVAL.NE.1) RETURN
      CALL AXIS(0.,0.,1H ,-1,10.,0.,0.,  X(LL+2) )                 98
      CALL AXIS(0.,0.,1H , 1, 4.,90.,0.,  Y(LL+2) )
C                                                                  101
      IC=201
      PHI=0.
      DO 300 I=1,IC
      X(I)=6378.*SIN(PHI)                                          107
      Y(I)=6378.*COS(PHI)                                          109
  300 PHI=PHI+.03141796
C
      CALL PRAM(X,Y,IC,XMIN1,YMIN1,XMAX1,YMAX1,10.,5.)             114
      CALL LINE(X,Y,IC,1,0,0)                                      116
      RETURN
C
      ENTRY CALCO1
C
      LVAL = 1
      KVAL = 1
      JVAL = 0
      CALL PLOTS(PLOAT(1),360 )                                    122
       CALL PLOT(0.,-11.0,-3)                                      124
       CALL PLOT(20.,0.5,-3)                                       126
      RETURN
C
      ENTRY CALCO2
C
      CALL PLOT(15.,0.,-3)                                         129
      CALL PLOT(0,0,999)                                           131
      RETURN
C
      ENTRY CALCO3
C
C
      CALL PLOT ( -17.5 , -5.0 , -3)                               134
      LVAL = LVAL + 1
      RETURN
      END
```

$IBFTC DENS

```
      SUBROUTINE DENSE                                                  DENS0004
      DIMENSION DD(3002) , SOA(3002)
      COMMON / RECT /    DD ,  SOA , LB
C                                                                       DENS0010
      COMMON /DATA/ RMAX(19),    EN,    DNDR,     DNDI,     DNDP,      DENS0011
     1              EMU(21)                                            DENS0012
C                                                                       DENS0013
      COMMON /HBANK1/ MODDER(7),   YO(11),   YD(11),   SCR(260)        DENS0014
      COMMON / RBLK1  /  STZMS , HPRIME , PKDELN , AMBDL , H0
C                                                                       DENS0015
C                                                                       DENS0015
      RPERD = 0.01745329
      RAD = 6378.
      DISMAX  =  2.0
      R = YO(1)
      TH     = YO(2)
C
      AMBDA  = AMBDL  * RPERD
C
      SNLAM1 = SIN( AMBDA )                                                2
      SNLAM2 = SNLAM1 * SNLAM1
      SNLAM3 = SNLAM2 * SNLAM1
C
      SNTH1  = SIN( TH )                                                   3
      SNTH2  = SNTH1 * SNTH1
      SNTH3  = SNTH2 * SNTH1
C
      CSTH1  = COS( TH )
C
      TNTH1  = TAN( TH )                                                   4
      TNTH2  = TNTH1 * TNTH1                                               5
C
      STSL   = SNTH1 / SNLAM1
C
      ZM1 = SQRT ( 4.0 - 3.0 * SNTH2  )                                    6
      ZM2 = SQRT ( 4.0 - 3.0 * SNLAM2 )                                    7
      ZM3 = ZM2 * SNTH3
      ZM4 = ZM1 * SNLAM3
      ZM5 = ZM3 / ZM4
C
      H = H0 * ZM5
      DIFF   =  1.0 - (RAD / R) * STSL * STSL
      TWO =  2.0 / TNTH1
      DTHETA =  DIFF * TWO / ( 1.0 + TWO * TWO )
      THETA1 = TH + DTHETA
C
      TNTH11 =  2.0 / TAN(THETA1)                                          8
      DIS  =  R * DIFF / SQRT( 1.0 + TNTH11 * TNTH11 )
C
C
C
C
C     CALCULATE  ELECTRON DENSITY OF F-REGION -ENF-
C                                                                          9
      W1     = (R - 6728.) / 50.0
```

```
      T17    = 0.5 * ( 1.0 - W1 - EXP(-W1) )                                  10
      ENF    = 2.765 * EXP(T17)
C     -                                                                       11
      DENFDR = -0.01 * ( 1.0 - EXP(-W1) ) * ENF
C
C     CALCULATE  ELECTRON DENSITY OF EXOSPHERE -ENX-
C                                                                             12
      ZX     = 6878.0 * ( 1.0 - 6878./R )
      DZXDR = (6878./YO(1))**2
      ENXR = SQRT(.9788*EXP(-ZX/66.546)+.0196*EXP(-ZX/265.98)+.0016*EXP(
     1 -ZX/1056.3))                                                           13   14   15   16
      ENXR   =  4.0 * ENXR
      ENX  = ENXR * ( 1.659E 5 * ABS( TH - 1.5707963 ) + 1662.0 )
      DENXDR = -.5*ENX/ENXR**2*DZXDR*(.9768/66.546*EXP(-ZX/66.546)+.0196
     1 /265.98*EXP(-ZX/265.98)+.0016/1056.3*EXP(-ZX/1056.3))                  17   18   19
      DENXDT =  1.659E 5 * ENXR / RPERD
      IF(YO(1)-7378.) 40,41,41
   40 FACTOR = EXP(-((YO(1)-7378.)/500.)**2 )                                 22
      ENX = ENX * FACTOR
      DENXDR = DENXDR*FACTOR - ENX*2.*(YO(1)-7378.)/500.**2
      DENXDT = DENXDT * FACTOR
   41 EN = ENX + ENF
C
C     CALCULATE  DERIVATIVES OF ELECTRON DENSITY
C
      PKFRAC = PKDELN/EN*(SIZM5/ZM5)
      FRACIN = PKFRAC * EXP(-(DIS/H)**2)
C
C                                                                             24
      DFDN = -2.*DIS/H**2 * FRACIN
      T31 = EN/(1.+FRACIN)*DFDN/(1.+4./TAN(THETA1)**2)                        25
      DNDR = DENFDR + DENXDR + T31
      CY02 = COS(YO(2))                                                       26
      DNDT = -CY02/ABS(CY02)*(DENXDT +EN/(1.+FRACIN)*DFDN/(1.+.25*TAN(
     1 THETA1)**2)*YO(1))                                                     27
  118 DNDP=      0.
      AY2 = YO(2)*57.29
    3 FORMAT ( 1H  ,4PE12.1,2PE12.3,1P8E11.3 )
C
C
      IF( DIS .GT. DISMAX ) GO TO 12
      IF( LB  .GT. 2998   ) GO TO 12
C
      LB = LB + 1
      DD(LB) = DIS
      COAM = COS(AMBDA)                                                       37
      SIAMS = SIN( AMBDA )**2                                                 38
      SL = SQRT(1.33333-SIAMS)                                                39
      ST = SQRT(1.33333-SIN(YO(2))**2 )                                       40   41
      SOA(LB) =.8660254/SIAMS*(COAM*SL-COS(YO(2) )*ST+ ALOG( (COAM+SL)/
     1  ( COS(YO(2) ) + ST ) )/3. )*RAD
C
C                                                                             42   43   44
   12 CONTINUE
      RETURN                                                          DENS0086
      END                                                             DENS0087
```

```
$IBFTC EIEL
```

```
      SUBROUTINE FIELD                                                  FIEL0002
      COMMON/EXFLD/D2CY1R,D2SY1R,D2CY2T,D2SY2I,D2CY3P,D2SY3P            FIEL0003
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,       FIEL0004
     1              PMIN,     PRNT,     RELERR,   A0,       B0,         FIEL0005
     2              R0,       THETA0,   PHI0,     PLUS,     NPOWER,     FIEL0006
     3              NPLOT,    J,        NUAR,     N1,       EN,         FIEL0007
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,     FIEL0008
     5              F,        F2,       C1,       FH,       COSPSI,     FIEL0009
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,     FIEL0010
     7              DCPDY2,   DCPDY3,   SP2,      FMUINT,   FMUS,       FIEL0011
     8              N,        GNU,      MUFLAG,   NTEST                 FIEL0012
      COMMON /HBANK1/ MORDER,   NOHALF,   NODOUB,   HBANK,    NOEQ,     FIEL0013
     1              FINVP,    FINVPI,   Y0(11),   YD(11),   MA(260)     FIEL0014
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,F1T,DNMNTR,DEL2S            FIEL0015
      COMMON /CKSR/ C,RCT,S,RST,Z,FM,TERM,TERM2,RMOD,RARG,Y06           FIEL0016
  100 F1T=1.+3.*C**2                                                    FIEL0017
      F2T=3.*S/F11*C                                                    FIEL0018
  101 RTF1T=SQRT(F11)                                                   FIEL0019    3
  102 FH=(6157.891/Y0(1))**3*RTF1T                                      FIEL0020
  103 DFHDR=-3.*FH/Y0(1)                                                FIEL0021
      DFHDT=-F2T*FH                                                     FIEL0022
  104 DFHDP=0.                                                          FIEL0023
  105 DNMNTR=RTYSQR*RTF1T                                               FIEL0024
  106 COSPSI=(2.*Y0(4)*C+Y0(5)*S)/DNMNTR                                FIEL0025
  107 SP2=1.-COSPSI**2                                                  FIEL0026
      IF (SP2 .LE. 0.0 )  SP2 = 0.0
      Y04S = S* Y0(4)                                                   FIEL0027
      Y05C = C* Y0(5)                                                   FIEL0028
      SINPSI = SIGN (SQRT (SP2),(Y05C*2. - Y04S))                       FIEL0029    12
      DCPDR=0.                                                          FIEL0030
      DCPDT = F2T * COSPSI + (Y05C - Y04S*2.)/ DNMNTR                   FIEL0031
      DCPDP=0.                                                          FIEL0032
      F1P=COSPSI/YSQUAR                                                 FIEL0033
      DCPDY1=2.*C/DNMNTR-Y0(4)*F1P                                      FIEL0034
      DCPDY2=S/DNMNTR-Y0(5)*F1P                                         FIEL0035
      DCPDY3=-Y0(6)*F1P                                                 FIEL0036
      D2CY2T=-Y0(5)*DCPDT/YSQUAR+4./DNMNTR*C/F1T                        FIEL0037
  108 D2SY2T=-(COSPSI*D2CY2T+DCPDT*DCPDY2/SINPSI**2)/SINPSI             FIEL0038
      RETURN                                                            FIEL0039
      END                                                               FIEL0040
```

$1BFTC POWFR

```
C                                                                       POWE0002
C     SUBROUTINE TO COMPUTE POWER LOSS                                  POWE0004
      SUBROUTINE POWERL                                                 POWE0005
      DIMENSION A(3,3),B(3,3)                                           POWE0006
      DIMENSION  YP(11)                                                 POWE0007
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,       POWE0008
     1              PMIN,     PRNT,     RELERR,   AO,       BO,         POWE0009
     2              RO,       THETAO,   PHIO,     PLUS,     NPOWER,     POWE0010
     3              NPLOT,    J,        NUAR,     N1,       FN,         POWE0011
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,     POWE0012
     5              F,        F2,       C1,       FH,       COSPSI,     POWE0013
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,     POWE0014
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   EMUS,       POWE0015
     8              N,        GNU,      MUFLAG                           POWE0016
      COMMON  /HBANK1/ MORDER,     NOHALF,   NODOUB,   HBANK,    NOEQ,   POWE0017
     1                 EINVP,     EINVPI,   YO(11),   YD(11),   MA(260) POWE0018
      COMMON /POWLOS/  COSA,       Y,        DMDR,     DMDT,     DMDP,   POWE0019
     1                 DMDY1,     DMDY2,    DMDY3,    DMDSI,    DMDDSI, POWE0020
     2                 DMUDR,     DMUDT,    DMUDP,    DMUDY1,   DMUDY2, POWE0021
     3                 DMUDY3,    DMUDSI,   EMU,      EMRAD             POWE0022
      COMMON /CKSR/ C,RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RANG,Y06           POWE0023
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,F1T,DNMNTR,DEL2S            POWE0024
      COMMON/EXFLD/D2CY1P,D2SY1R,D2CY2T,D2SY2T,D2CY3P,D2SY3P             POWE0025
      EQUIVALENCE(YP(1),YO(1))                                          POWE0026
C                                                                       POWE0027
C     COMPUTE MISCELLANEOUS VARIABLES                                   POWE0028
C                                                                       POWE0029
  500 Y2=Y**2                                                           POWE0030
      TERMC1 = TERM*C1                                                  POWE0031
      COSPS2 = COSPSI**2                                                POWE0032
      AA2 = EMD**2                                                      POWE0033
      YC = Y2*COSPS1                                                    POWE0034
      AA2C1 = AA2*C1                                                    POWE0035
      ENDA2C = EN/AA2C1                                                 POWE0036
      XTERM=ENDA2C/(2.*EMU)                                             POWE0037
      EMRAD2=EMRAD**2                                                   POWE0038
      FHCSP2=2.*FH*COSPSI                                               POWE0039
  501 F2C=FH/F2*COSPS2                                                  POWE0040
  502 IF(MUFLAG)79,80,79                                                POWE0041
   80 TO=THETAO/57.2957795                                              POWE0042
      PO=PHIO/57.2957795                                                POWE0043
      SIPO=SIN(PO)                                                      POWE0044  6
      COPO=COS(PO)                                                      POWE0045  7
      SITO=SIN(TO)                                                      POWE0046  8
      COTO=COS(TO)                                                      POWE0047  9
      RO2=RO**2                                                         POWE0048
  503 MUFLAG = 1                                                        POWE0049
   79 COP=COS(YP(3))                                                    POWE0050  12
      SIP=SIN(YP(3))                                                    POWE0051  13
      SIPMP=SIN(YP(3)-PO)                                               POWE0052  14
      COPMP=COS(YP(3)-PO)                                               POWE0053  15
  504 RP2=   (RO2+YP(1)**2-2.0*YP(1)*RO*(SITO*S*COPMP                   POWE0054
     1+COTO*C))                                                         POWE0055
     2 RP=SQRT(RP2)                                                     POWE0056  18
      COTP=(RCT-RO*COTO)/RP                                             POWE0057
```

```
      10 SITP=SQRT(1.-COTP**2)                                          POWE0058    20
     505 COPP=(RST*COP-RO*STTO*COPO)/RP/SITP                            POWE0059
     506 DRPDR=(YP(1)-RO*(STTO*S*COPMP+COTO*C))/RP                      POWE0060
         DRPDT=-RO*YP(1)*(STTO*C*COPMP-COTO*S)/RP                       POWE0061
     507 DRPDP=RO*YP(1)*SITO*S*SIPMP/RP                                 POWE0062
     508 A(1,1)=YP(1)-RO*(STTO*S*COPMP+COTO*C)                          POWE0063
         A(1,2)=RO*(RST*COTO-RCT*SITO*COPMP)                            POWE0064
         A(1,3)=RST*RO*SITO*SIPMP                                       POWE0065
         A(2,1)=S*COP                                                   POWE0066
         A(2,2)=RCT*COP                                                 POWE0067
         A(2,3)=-RST*SIP                                                POWE0068
         A(3,1)=C                                                       POWE0069
         A(3,2)=-RST                                                    POWE0070
         A(3,3)=0.0                                                     POWE0071
         B(1,1)=RP                                                      POWE0072
         B(2,1)=SITP*COPP                                               POWE0073
         B(3,1)=COTP                                                    POWE0074
         B(1,2)=0.0                                                     POWE0075
     509 B(2,2)=RP*COTP*COPP                                            POWE0076
     510 CALL MINV(3,A,B)                                               POWE0077    27
         DRDRP=A(1,1)                                                   POWE0078
         DTDRP=A(2,1)                                                   POWE0079
     511 DPDRP=A(3,1)                                                   POWE0080
C                                                                       POWE0081
C    CALCULATE INTERMEDIATE DERIVATIVES                                 POWE0082
C                                                                       POWE0083
     512 D2MY1R = -(FHCSP2*DCPDY1/F2*DFHDR-YC*DCPDY1*                   POWE0084
        1         (DCPDR/SINPSI*COSPS1-DNDR/TERMC1)-                   POWE0085
        2          FH**2*SINPSI/F2*D2SY1R)/TERM                        POWE0086
         D2MY2T=-(FHCSP2*DCPDY2/F2*DFHDT-YC*DCPDY2*                     POWE0087
        1(DCPDT/SINPSI*COSPS1/SINPSI-DNDT/TERMC1)-                      POWE0088
        2FH**2*SINPSI/F2*D2SY2T)/TERM                                   POWE0089
     513 D2MY3P=-(FHCSP2*DCPDY3/F2*DFHDP-YC*DCPDY3*                     POWE0090
        1         (DCPDP/SINPSI*COSPS1-DNDP/TERMC1)-                   POWE0091
        2          FH**2*SINPSI/F2*D2SY3P)/TERM                        POWE0092
C                                                                       POWE0093
     514 D2AY1R= -D2MY1R + (DMDR*DMDY1+EM * D2MY1R                      POWE0094
        1         +(FHCSP2/F2*DFHDR+Y2*DCPDR)*DCPDY1+YC*D2CY1R         POWE0095
        2         -(EM*DMDR+DFHDR*F2C+YC*DCPDR)                        POWE0096
        3         *(EM*DMDY1+YC*DCPDY1)/EMRAD2) / EMRAD                POWE0097
         D2AY2T=-D2MY2T+(DMDT*DMDY2+EM*D2MY2T+                          POWE0098
        1(FHCSP2/F2*DFHDT+Y2*DCPDT)*DCPDY2+YC*D2CY2T                    POWE0099
        2-(EM*DMDT+DFHDT*F2C+YC*DCPDT)                                  POWE0100
        3*(EM*DMDY2+YC*DCPDY2)/EMRAD2)/EMRAD                            POWE0101
     515 D2AY3P= -D2MY3P + (DMDP*DMDY3+EM * D2MY3P                      POWE0102
        1         +(FHCSP2/F2*DFHDP+Y2*DCPDP)*DCPDY3+YC*D2CY3P         POWE0103
        2         -(EM*DMDP+DFHDP*F2C+YC*DCPDP)                        POWE0104
        3         *(EM*DMDY3+YC*DCPDY3)/EMRAD2) / EMRAD                POWE0105
C                                                                       POWE0106
C    DERIVATIVES OF A WITH RESPECT TO,Y1,Y2,Y3,PHI,THETA,R              POWE0107
C                                                                       POWE0108
     516 DADY1 = -DMDY1+(EM*DMDY1+YC*DCPDY1)/EMRAD                      POWE0109
         DADY2 = -DMDY2+(EM*DMDY2+YC*DCPDY2)/EMRAD                      POWE0110
         DADY3 = -DMDY3+(EM*DMDY3+YC*DCPDY3)/EMRAD                      POWE0111
         DADR= -DMDR+(EM*DMDR +F2C * DFHDR +YC *DCPDR)/ EMRAD           POWE0112
         DADT  = -DMDT+(EM*DMDT+F2C*DFHDT+YC*                           POWE0113
```

```
     1DCPDT)/EMRAD                                                      POWE0114
  517 DADP= -DMDP+(EM*DMDP +F2C * DFHDP +YC *DCPDP)/ EMRAD              POWE0115
  518 DBDR=DADR+DMDR                                                    POWE0116
      DBDT=DADT+DMDT                                                    POWE0117
      DBDP=DADP+DMDP                                                    POWE0118
  519 DBDSI=DMDDSI+DMDSI                                                POWE0119
C                                                                       POWE0120
  520 D2MDSR=(FHCSP2*SINPSI*DFHDR+FH*FH*(-COSPS2/SINPSI+SINPSI)*        POWE0121
     1        DCPDR+FHCSP2*FH/C1*SINPSI/TERM*DNDR)/F2/TERM             POWE0122
      D2MDST=(FHCSP2*SINPSI*DFHDT+FH*FH*(-COSPS2/SINPSI+SINPSI)*        POWE0123
     1        DCPDT+FHCSP2*FH/C1*SINPSI/TERM*DNDT)/F2/TERM             POWE0124
  521 D2MDSP=(FHCSP2*SINPSI*DFHDP+FH*FH*(-COSPS2/SINPSI+SINPSI)*        POWE0125
     1        DCPDP+FHCSP2*FH/C1*SINPSI/TERM*DNDP)/F2/TERM             POWE0126
C                                                                       POWE0127
C     SECOND DERIVATIVES OF MU                                          POWE0128
C                                                                       POWE0129
  522 D2UDSR= -DMUDSI/EMU*DMUDR-DMUDR/EMD*DMDDSI + XTERM *              POWE0130
     1        (-D2MDSR-DMDR/EMRAD*DBDSI+(DMDSI*DMDR+EM*D2MDSR          POWE0131
     2        -2.*F2C/COSPSI*SINPSI*DFHDR-Y2*SINPSI*DCPDR +YC* COSPSI  POWE0132
     3        /SINPSI*DCPDR)/EMRAD)-XTERM*DADR/EMD*DMDDSI              POWE0133
      D2UDST=-DMUDSI/EMU*DMUDT-DMUDT/EMD*DMDDSI+XTERM*                  POWE0134
     1(-D2MDST-DBDT/EMRAD*DBDSI+(DMDSI*DMDT+EM*D2MDST                   POWE0135
     2-2.*F2C/COSPSI*SINPSI*DFHDT-Y2*SINPSI*DCPDT+YC*COSPSI             POWE0136
     3/SINPSI*DCPDT)/EMRAD)-XTERM*DADT/EMD*DMDDSI                       POWE0137
      D2UDSP= -DMUDSI/EMU*DMUDP-DMUDP/EMD*DMDDSI + XTERM *              POWE0138
     1        (-D2MDSP+(DMDSI*DMDP+EM*D2MDSP                           POWE0139
     2        -2.*F2C/COSPSI*SINPSI*DFHDP-Y2*SINPSI*DCPDP +YC* COSPSI  POWE0140
     3        /SINPSI*DCPDP)/EMRAD -DBDP/EMRAD*DBDSI-DADP/EMD*DMDDSI)  POWE0141
      D2UY1R =((DADY1/AA2C1)*(DNDR-2.*EN/EMU*DADR)                      POWE0142
     1+D2AY1R*ENDA2C-2.*DMUDR*DMUDY1)/2./EMU                            POWE0143
      D2UY2T = ((DADY2/AA2C1)*(DNDT-2.*EN/EMD*DADT)                     POWE0144
     1+ENDA2C*D2AY2T-2.*DMUDT*DMUDY2)/2./EMU                            POWE0145
  523 D2UY3P = ((DNDP/AA2C1-2.*ENDA2C*DADP/EMD)*DADY3+                  POWE0146
     1ENDA2C*D2AY3P-2.*DMUDP*DMUDY3)/(2.*EMU)                           POWE0147
C                                                                       POWE0148
  524 YPEMDU = YP(4)-EMU*DMUDY1                                         POWE0149
      YP2MDU = YP(5)-EMU*DMUDY2                                         POWE0150
  525 YP3MDU = YP(6)-EMU*DMUDY3                                         POWE0151
C                                                                       POWE0152
  526 XTEM2=EMUS+DMUDSI**2                                              POWE0153
      XTEM=SQRT(XTEM2)                                                  POWE0154   45
      DMUDRP=DMUDR*DRDRP+DMUDT*DTDRP+DMUDP*DPDRP                        POWE0155
      DUDSRP=D2UDSR*DRDRP+D2UDST*DTDRP+D2UDSP*DPDRP                     POWE0156
      DUY1RP=D2UY1R*DRDRP                                               POWE0157
      DUY2RP=D2UY2T*DTDRP                                               POWE0158
  527 DUY3RP=D2UY3P*DPDRP                                               POWE0159
  528 RDOTP=(DRPDR*YPEMDU+DRPDT*YP2MDU/YP(1)+DRPDP*YP3MDU/RST)          POWE0160
     1/XTEM                                                             POWE0161
  529 DEL2S=(2.0*EMU/RP+DMUDRP)*RDOTP-EMU*RDOTP/XTEM2*(EMU*DMUDRP       POWE0162
     1+DMUDSI*DUDSRP)-EMU/XTEM*(DRPDR*(DMUDRP*DMUDY1+EMU*DUY1RP)+DRPDT/YPOWE0163
     2P(1)*(YP2MDU/YP(1)*DRDRP+DMUDRP*DMUDY2+EMU*DUY2RP)+DRPDP/RST*     POWE0164
     3((1.0/YP(1)*DRDRP+C/S*DTDRP)*YP3MDU+DMUDRP*DMUDY3+EMU*DUY3RP))    POWE0165
  530 YD(11)=DEL2S/EMUS/COSA                                            POWE0166
      RETURN                                                            POWE0167
      END                                                               POWE0168
```

SIBFTC FORC

```
      SUBROUTINE FORCE                                                  FORC0002
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,     FORC0003
     1              PMIN,     PRNT,     RELERR,   A0,       R0,       FORC0004
     2              R0,       THETA0,   PHI0,     PLUS,     NPOWER,   FORC0005
     3              NPLOT,    J,        NUAR,     N1,       FN,       FORC0006
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,   FORC0007
     5              F,        F2,       C1,       FH,       COSPSI,   FORC0008
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,   FORC0009
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   FMUS,     FORC0010
     8              N,        GNU,      MUFLAG                          FORC0011
      COMMON /HBANK1/ MORDER,     NOHALF,   NODOUB,   HBANK,    NOEQ,   FORC0012
     1                FINVP,     FINVPI,   Y0(11),   YD(11),   MA(260) FORC0013
  100 YNRMLZ=EMU/RTYSQR                                                 FORC0014
  101 Y0(4)=YNRMLZ*Y0(4)                                                FORC0015
      Y0(5)=YNRMLZ*Y0(5)                                                FORC0016
  102 Y0(6)=YNRMLZ*Y0(6)                                                FORC0017
      RETURN                                                            FORC0018
      END                                                               FORC0019
```

SIBEIC COL

COL - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE COLL( YO1,YO2,YO3,GNU )
C
C
C   RADIUS OF WAVE FRONT IN KM              YO1
C   COLATITUDE OF WAVE FRONT IN RADIANS     YO2
C   LONGITUDE OF WAVE FRONT IN RADIANS      YO3
C   COLLISION FREQUENCY                     GNU
C
C
      DIMENSION  A(6) , B(6) ,
     1           C(3) , D(3)
      DATA  A /  5.0562E 0, -3.7482E-2 ,  1.3864E-4 ,
     1          -1.4777E-7, -4.8192E-1 , -2.7021E-1 /
      DATA  B /  3.2512E-2, -8.8470E-3 ,  8.5410E-5 ,
     1          -1.5422E-7, -1.4700E-2 ,  6.5037E-1 /
      DATA  C / -3.5818E-1,  1.1250E 0 , -8.8304E-1 /
      DATA  D / -1.7828E-1,  5.5997E 0 ,  5.6028E 0 /
C                                                                      COLL0020
C                                                                      COLL0021
      X = YO1 - 6378.0
    4 IF(X-100.) 5,5,6                                                 COLL0023
    5 GNU=12.0*3527-.0739*X                                            COLL0024
    9 GNU=10.**GNU                                                     COLL0025     6
      RETURN                                                           COLL0026
    6 COEFF=(C(1)*YO2+C(2))*YO2+C(3)+((D(1)*YO2+D(2))*YO2              COLL0027
     1  +D(3))*COS(YO3)                                               COLL0028     8
   65 IF(X-475.) 7,8,8                                                 COLL0029
    7 X=X-100.                                                         COLL0030
      XFAC=X*.015708                                                   COLL0031
      S=SIN(XFAC)                                                      COLL0032    12
      E=COS(XFAC)                                                      COLL0033    13
   75 GNU=((A(4)*X+A(3))*X+A(2))*X+A(1)+A(5)*E+A(6)*S+(((B(4)*X+B(3))*X COLL0034
     1+B(2))*X+B(1)+B(5)*E+B(6)*S)*COEFF                               COLL0035
      GO TO 9                                                          COLL0036
    8 X=X-475.                                                         COLL0037
   85 GNU=2.3653-.0030266*X+(.3195+.00005546*X)*COEFF                  COLL0038
      GO TO 9                                                          COLL0039
      END                                                              COLL0040
```

$IBFTC CST

```
      SUBROUTINE CSINT (XX,CI,SI)                                       CST10002
 5001 DIMENSION  A0(4),A2(4),A4(4),A6(4),BP(4)                          CST10003
      DATA  A0/38.102495,157.10542,21.821899,449.69033/,                CST10004
     1      A2/335.67732,570.23628,352.01650,1114.9789/,                CST10005
     1      A4/265.18703,322.62491,302.75787,482.48598/,                CST10006
     3      A6/38.027264,40.021433,42.242655,48.196927/                 CST10007
      X = ABS (XX)                                                      CST10008
    5 M=1                                                               CST10009
    6 MM=1                                                              CST10010
    7 IF (X-1.0) 400,4,4                                                CST10011
    4 POFX=0.0                                                          CST10012
      QOFX=0.0                                                          CST10013
      POLD=0.0                                                          CST10014
      QOLD=0.0                                                          CST10015
      S GN = +1.0                                                       CST10016
      ERROR = 1.0 E -8                                                  CST10017
   20 DO 40   N=1,15                                                    CST10018
      NN=2*N-2                                                          CST10019
      NNN=NN+1                                                          CST10020
      BN=2*N                                                            CST10021
      CN=BN-1.0                                                         CST10022
   21 IF  (M)     30 ,22, 22                                           CST10023
   22 POFX = POLD + S GN*TOR(NN)/X**CN                                  CST10024  16   17
   24 IF (ABS (ABS (POLD/POFX)-1.0)-ERROR)   25, 25,26                  CST10025
   25  M=-1                                                            CST10026
      GO TO 30                                                          CST10027
   26 POLD=POFX                                                         CST10028
   30 IF (MM)    35,31 ,31                                            CST10029
   31 QOFX = QOFX + S GN*TOR(NNN)/X**BN                                 CST10030  26   27
   33 IF (ABS (ABS (QOLD/QOFX)-1.0)-ERROR)    34, 34, 36                CST10031
   34 MM = -1                                                           CST10032
   35 IF (M) 41,40,40                                                   CST10033
   36 QOLD = QOFX                                                       CST10034
   40 S GN = -S GN                                                      CST10035
   41 SI=1.5707963-POFX*COS (X)-QOFX*SIN (X)                            CST10036  38   39
   42 CI=POFX*SIN (X)-QOFX*COS (X)                                      CST10037  41   42
      GO TO 500                                                         CST10038
  400 IF (X)  401,402,409                                               CST10039
  401 WRITE(6,1000)                                                     CST10040  46
 1000 FORMAT(1H15X22HX LESS THAN 0. IN CSI1)                            CST10041
      CALL EXIT                                                         CST10042  47
  402 SI=0.0                                                            CST10043
  403 CI=-9.99E+30                                                      CST10044
  404 RETURN                                                            CST10045
  409 IF (X-1.0)  410,5002,5002                                         CST10046
  410 P = X                                                             CST10047
      PP = X**2                                                         CST10048
      PPP = PP**2                                                       CST10049
      SI = X*(1.0-PP/18.0)                                              CST10050
  411 Q = 0.5*PP                                                        CST10051
      CI = 0.57721567 +ALOG (X) + 0.25*PP*(-1.0+PP/24.0)                CST10052  55
   55 ERROR =  1.0 E  -15                                               CST10053
  420 DO 440 N =2,50                                                    CST10054
      AN = N                                                            CST10055
      BN = 2.0*AN                                                       CST10056
```

```
      CN = BN*2.0                                                       CST10057
  421 IF (M) 430,422,422                                                CST10058
  422 P = P*PPP/((CN-3.0)*(CN-4.0)*(CN-5.0)*(CN-6.0))                   CST10059
      TERM = P*(1.0/(CN-3.0)-PP/(((CN-1.0)**2)*(CN-2.0)))               CST10060
      IF (ABS (TERM)-ERROR)  425,425,424                                CST10061
  424 SI = SI + TERM                                                    CST10062
      GO TO 430                                                         CST10063
  425 M=-1                                                              CST10064
  430 IF (MM)  435,431,431                                              CST10065
  431 Q = Q*PPP/((CN-2.0)*(CN-3.0)*(CN-4.0)*(CN-5.0))                   CST10066
      TERM = -Q*(1.0/(CN-2.0)-PP/((CN-1.0)*CN**2))                      CST10067
      IF (ABS (TERM) - EPROR )  434,434,433                             CST10068
  433 CI = CI + TERM                                                    CST10069
      GO TO 435                                                         CST10070
  434 MM=-1                                                             CST10071
  435 IF (M)   500,440,440                                              CST10072
  440 CONTINUE                                                          CST10073
  500 IF(XX)  501,503,503                                               CST10074
  501 SI=-SI                                                            CST10075
  503 RETURN                                                            CST10076
 5002 CONTINUE                                                          CST10077
 5005 XSQ=X**2                                                          CST10078
      REC=1.0/XSQ                                                       CST10079
 5006 DO 5007 I=1,4                                                     CST10080
 5007 QP(I)=REC*(REC*(REC*AU(I)+A2(I))+A4(I))+A6(I)+XSQ                 CST10081
 5008 P = QP(1)/(QP(2)*X)                                               CST10082
      Q = QP(3)*REC/QP(4)                                               CST10083
 5009 CC = COS (X)                                                      CST10084   100
      SS = SIN (X)                                                      CST10085   101
 5010 SI = 1.5707963 -P*CC-Q*SS                                         CST10086
      CI = P*SS-Q*CC                                                    CST10087
 5011 GO TO 500                                                         CST10088
      END                                                               CST10089
```

$IBFTC POLA

```
C                                                                       POLA0002
C     SUBROUTINE TO COMPUTE POLARIZATION                                POLA0003
C                                                                       POLA0004
      SUBROUTINE POLAR                                                  POLA0005
C                                                                       POLA0006
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,       POLA0007
     1              PMIN,     PRNT,     RELERR,   AO,       BO,         POLA0008
     2              RO,       THETAO,   PHIO,     PLUS,     NPOWER,     POLA0009
     3              NPLOT,    J,        NUAR,     N1,       FN,         POLA0010
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,     POLA0011
     5              F,        F2,       C1,       FH,       COSPSI,     POLA0012
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,     POLA0013
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   EMUS,       POLA0014
     8              N,        GNU,      MUFLAG,   NTEST                 POLA0015
C                                                                       POLA0016
      COMMON  /HBANK1/ MORDER,     NOHALF,   NODOUB,   HBANK,    NOEQ,  POLA0017
     1                 FINVP,      FINVPI,   YO(11),   YD(11),  MA(260)POLA0018
C                                                                       POLA0019
      COMMON / CRSR / C, RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RARG,YO6        POLA0020
C                                                                       POLA0021
      COMPLEX R,XMZ                                                     POLA0022
      Y      =  FH / F
      YL     =   Y * COSPSI
      YT     =   Y * SINPSI
      YL2    =  YL * YL
      YT2        =  ( YT * YT ) / 2.0
      YT4        =  YT2 * YT2
      XMZ=CMPLX(TERM,-Z)                                                POLA0029
  101 R=CMPLX(0.,-1./YL)*(YT2/XMZ-PLUS*CSQRT(YT4/XMZ+YL2))              POLA0030   3
  102 RMOD=CABS(R)                                                      POLA0031   5
  103 RARG=ATAN2(AIMAG(R),REAL(R))                                      POLA0032   7
      RETURN                                                            POLA0033
      END                                                               POLA0034
```

$IBFTC 10

```
      FUNCTION TOR(N)                                          TOR 0002
      X = N                                                    TOR 0003
      TEMP=N**N                                                TOR 0004    2
      NOR=TEMP*EXP(-X)*SQRT(6.2831853*X)+.1                    TOR 0005    3     4
      TOR=NOR                                                  TOR 0006
      RETURN                                                   TOR 0007
      END                                                      TOR 0008
```

```
      SUBROUTINE MINV(N,A,B)                                          MINV0004
      DIMENSION A(3,3),B(3,3),IPIV(3)                                 MINV0005
      DO 1 I=1,N                                                      MINV0006
    1 IPIV(I)=I                                                       MINV0007
      NMI=N-1                                                         MINV0008
      DO 2 I=1,NMI                                                    MINV0009
      IMAX = I                                                        MINV0010
      IPI = I+1                                                       MINV0011
      DO 5 J=IPI,N                                                    MINV0012
      IPJ = IPIV(J)                                                   MINV0013
      IPMAX =IPIV(IMAX)                                               MINV0014
      IF(ABS(A(IPJ,I))-ABS(A(IPMAX,I))) 5,5,6                         MINV0015
    6 IMAX=J                                                          MINV0016
    5 CONTINUE                                                        MINV0017
      TEMP=IPIV(IMAX)                                                 MINV0018
      IPIV(IMAX)=IPIV(I)                                              MINV0019
      IPIV(I)=TEMP                                                    MINV0020
      IPIVI=IPIV(I)                                                   MINV0021
      A(IPIVI,I)=1.0/A(IPIVI,I)                                       MINV0022
      DO 7 J=IPI,N                                                    MINV0023
      IPJ = IPIV(J)                                                   MINV0024
      A(IPJ,I)=A(IPJ,I)*A(IPIVI,I)                                    MINV0025
      DO 8 K=IPI,N                                                    MINV0026
    8 A(IPJ,K)=A(IPJ,K)-A(IPJ,I)*A(IPIVI,K)                           MINV0027
    7 CONTINUE                                                        MINV0028
    2 CONTINUE                                                        MINV0029
      IPN=IPIV(N)                                                     MINV0030
      A(IPN,N)=1.0/A(IPN,N)                                           MINV0031
      DO 9 I=1,NMI                                                    MINV0032
      IPIVI=IPIV(I)                                                   MINV0033
      IPI=I+1                                                         MINV0034
      DO 10 J=IPI,N                                                   MINV0035
      IPJ=IPIV(J)                                                     MINV0036
      DO 11 K=1,N                                                     MINV0037
   11 B(IPJ,K)=B(IPJ,K)-A(IPJ,I)*B(IPIVI,K)                           MINV0038
   10 CONTINUE                                                        MINV0039
    9 CONTINUE                                                        MINV0040
      DO 12 I=1,N                                                     MINV0041
      ICOMP=N-I+1                                                     MINV0042
      IPCO=IPIV(ICOMP)                                                MINV0043
      ICOPI=ICOMP+1                                                   MINV0044
      IF(N-ICOPI) 13,14,14                                            MINV0045
   14 DO 15 J=ICOPI,N                                                 MINV0046
      IPJ=IPIV(J)                                                     MINV0047
      DO 16 K=1,N                                                     MINV0048
   16 B(IPCO,K)=B(IPCO,K)-A(IPCO,J)*B(IPJ,K)                          MINV0049
   15 CONTINUE                                                        MINV0050
   13 DO 17 K=1,N                                                     MINV0051
   17 B(IPCO,K)=A(IPCO,ICOMP)*B(IPCO,K)                               MINV0052
   12 CONTINUE                                                        MINV0053
      DO 30 I=1,N                                                     MINV0054
      IPIVI=IPIV(I)                                                   MINV0055
      DO 30 J=1,N                                                     MINV0056
   30 A(I,J)=B(IPIVI,J)                                               MINV0057
      RETURN                                                          MINV0058
```

```
      END                                                    MINV0059
```

STORAGE MAP

MAIN PROGRAM

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00054

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I	NTEST	00053	I			

COMMON BLOCK HBANK1 ORIGIN 00055 LENGTH 00441

MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						

COMMON BLOCK CRSR ORIGIN 00516 LENGTH 00013

C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	YO6	00012	R			

COMMON BLOCK NEW ORIGIN 00531 LENGTH 00002

PLOTO	00000	R	RDOT	00001	R

COMMON BLOCK EPSTN ORIGIN 00533 LENGTH 00002

EPSTIN	00000	R	PROPT	00001	R

COMMON BLOCK RSN ORIGIN 00535 LENGTH 00001

IRSN	00000	I

COMMON BLOCK GAUSS ORIGIN 00536 LENGTH 00007

YSQUAR	00000	R	DCPDR	00001	R	DCPDP	00002	R
DFHDP	00003	R	FIT	00004	R	DNMNTR	00005	R
DEL2S	00006	R						

COMMON BLOCK POWLOS ORIGIN 00545 LENGTH 00023

COSA	00000	R	Y	00001	R	DMDR	00002	R
DMDT	00003	R	DMDP	00004	R	DMDY1	00005	R
DMDY2	00006	R	DMDY3	00007	R	DMDSI	00010	R
DMDDSI	00011	R	DMUDR	00012	R	DMUDT	00013	R
DMUDP	00014	R	DMUDY1	00015	R	DMUDY2	00016	R

MAIN STORAGE MAP

DMUDY3	00017	R	DMUDS1	00020	R	EMD	00021	R
EMRAD	00022	R						
COMMON BLOCK			RECT	ORIGIN	00570	LENGTH	13565	
DD	00000	R	SUA	05672	R	LB	13564	I
COMMON BLOCK			ROOTS	ORIGIN	14355	LENGTH	00002	
JUMP	00000	I	MYD1	00001	I			
COMMON BLOCK			CONST	ORIGIN	14357	LENGTH	00007	
ORDER	00000	R	EUBAR	00001	R	ELBAR	00002	R
YCLOW	00003	R	HMAXT	00004	R	HMINT	00005	R
KD	00006	I						
COMMON BLOCK			GRAPH1	ORIGIN	14366	LENGTH	00010	
XMAX1	00000	R	XMIN1	00001	R	YMAX1	00002	R
YMIN1	00003	R	DATE	00004	R			
COMMON BLOCK			GRAPH0	ORIGIN	14376	LENGTH	00023	
XMAX0	00000	R	XMIN0	00001	R	YMAX0	00002	R
YMIN0	00003	R	PLT	00004	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
ND	14421	I	PRNTO	14422	R	PLOTT	14423	R
TESTJ	14424	R	I1	14425	I	NRTN	14426	I
NTRG	14427	I	YADD	14430	R	X	14431	R
YT	14432	R	YT2	14433	R	YL	14434	R
YL2	14435	R	YLY1	14436	R	DMD	14437	R
DMN1	14440	R	DMN2	14441	R	DMT1	14442	R
DMT2	14443	R	DMUN1	14444	R	DMUN2	14445	R
DMD1	14446	R	DMUD1	14447	R	DMUN3	14450	R
DMDF	14451	R	DMUDF	14452	R	EMZ	14453	R
A	14454	R	B	14455	R	U	14456	R
V	14457	R	W	14460	R	CAPPA	14461	R
THETA	14462	R	RAD	14463	R	EMUPI	14464	R
PI	14465	R	CIMUPI	14466	R	SIMUPI	14467	R
PI2	14470	R	CIM2PI	14471	R	SIM2PI	14472	R
EMUPI2	14473	R	PIO2	14474	R	DENOM	14475	R
RO2	14476	R	R2	14477	R	PP2	14500	R
RP	14501	R	PSI	14502	R			

ENTRY POINTS

..... SECTION 15

SUBROUTINES CALLED

INPUT	SECTION	16	ON	SECTION	17	OFF	SECTION	18
SMARK	SECTION	19	COS	SECTION	20	SIN	SECTION	21
SQRT	SECTION	22	DENSE	SECTION	23	.FWRD.	SECTION	24
COLL	SECTION	25	FIELD	SECTION	26	FORCE	SECTION	27

STORAGE MAP

POWERL	SECTION	28	TRA14	SECTION	29	OUTPUT	SECTION	30
CSINT	SECTION	31	ALOG	SECTION	32	ARCOS	SECTION	33
TRA24	SECTION	34	.EXIT.	SECTION	35	.FXEM.	SECTION	36
.UNU6.	SECTION	37	.FFIL.	SECTION	38	.FCNV.	SECTION	39
CC.1	SECTION	40	CC.2	SECTION	41	CC.3	SECTION	42
CC.4	SECTION	43	SYSLOC	SECTION	44			

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
102	1A	14562	39	6A	14571	104	11A	14576
20	21A	14623	105	26A	14631	1047	31A	14644
106	33A	14705	40	87A	15755	41	34A	14717
42	89A	15760	43	152A	16417	50	41A	14747
107	45A	14756	2000	49A	14772	2001	51A	15003
2002	FORMAT	14543	4001	99A	16026	108	52A	15003
110	55A	15021	2003	60A	15102	2004	62A	15113
2005	FORMAT	14550	116	63A	15113	117	65A	15120
118	67A	15123	119	68A	15163	120	69A	15170
121	70A	15245	122	71A	15254	123	72A	15414
124	73A	15435	125	76A	15534	126	77A	15552
127	78A	15571	128	79A	15606	129	81A	15622
130	82A	15744	131	83A	15747	132	92A	15770
133	94A	15774	44	95A	16014	45	109A	16052
908	97A	16022	47	107A	16044	46	143A	16376
4000	105A	16041	134	111A	16056	135	113A	16062
136	115A	16066	1046	119A	16100	137	121A	16107
140	125A	16131	141	137A	16325	142	144A	16400
143	145A	16401	144	147A	16405	145	149A	16411
146	150A	16414	FORMAT	1000	14555			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 16454.

INPU 02/06/69 PAGE

STORAGE MAP

SUBROUTINE INPUT

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00053

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PKNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						

COMMON BLOCK HBANK1 ORIGIN 00054 LENGTH 00441

MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	Y0	00007	R	YD	00022	R
MA	00035	I						

COMMON BLOCK CRSR ORIGIN 00515 LENGTH 00013

C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	EM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

COMMON BLOCK CONST ORIGIN 00530 LENGTH 00007

ORDER	00000	R	EUBAR	00001	R	FLBAR	00002	R
YCLOW	00003	R	HMAXT	00004	R	HMINT	00005	R
KD	00006	I						

COMMON BLOCK NEW ORIGIN 00537 LENGTH 00002

PLOT0	00000	R	RUOT	00001	R			

COMMON BLOCK RECT ORIGIN 00541 LENGTH 13565

DD	00000	R	SOA	05672	R	LB	13564	I

COMMON BLOCK RSN ORIGIN 14326 LENGTH 00001

IRSN	00000	I						

COMMON BLOCK RBLK1 ORIGIN 14327 LENGTH 00005

STZM5	00000	R	HPRIME	00001	R	PKDELN	00002	R
AMBDL	00003	R	HU	00004	R			

COMMON BLOCK GRAPHU ORIGIN 14334 LENGTH 00023

XMAX0	00000	R	XMIN0	00001	R	YMAX0	00002	R

STORAGE MAP

YMIN0	00003	R	PLT	00004	R			

COMMON BLOCK GRAPH1 ORIGIN 14357 LENGTH 00010

XMAX1	00000	R	XMIN1	00001	R	YMAX1	00002	R
YMIN1	00003	R	DATE	00004	R			

COMMON BLOCK GRAPH2 ORIGIN 14367 LENGTH 00024

TITLE	00000	R

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
V	14413	R	W	14416	R	D	14421	R

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
LAST	14457	I	NTITLE	14460	I	NCONST	14461	I
LIMITS	14462	I	RAD	14463	R	RPERD	14464	R
REARTH	14465	R	DELAO	14466	R	PRINT	14467	R
PLINT	14470	R	MODE	14471	I	JTEST	14472	I
NOVER	14473	I	NAUTO	14474	I	PKFRAC	14475	R
AMBDA	14476	R	THO	14477	R	SNLAM1	14500	R
SNLAM2	14501	R	SNLAM3	14502	R	SNTHO1	14503	R
SNTHO2	14504	R	SNTHO3	14505	R	TNTHO1	14506	R
TNTHO2	14507	R	STSL	14510	R	ZM1	14511	R
ZM2	14512	R	ZM3	14513	R	ZM4	14514	R
ZM5	14515	R	H	14516	R	HPRIM1	14517	R
WALSH1	14520	R	WALSH2	14521	R	WALSH3	14522	R
W1	14523	R	T17	14524	R	FNF	14525	R
ZX	14526	R	ENXR	14527	R	FNX	14530	R
TM	14531	R	FACTOR	14532	R	H1	14533	R
A	14534	R	B	14535	R	Y	14536	R
YO42	14537	R	YO52	14540	R	YO62	14541	R
YSQUAR	14542	R	Y	14543	R	YT	14544	R
YT2	14545	R	YL	14546	R	YL2	14547	R
YLYT	14550	R	EMRAD	14551	R	EMD	14552	R
EMUZ	14553	R	EL	14554	R			

ENTRY POINTS

INPUT SECTION 13

SUBROUTINES CALLED

.FRDO.	SECTION	14	.FRDD.	SECTION	15	.FSLI.	SECTION	16
SIN	SECTION	17	TAN	SECTION	18	SQRT	SECTION	19
ATAN	SECTION	20	EXP	SECTION	21	COS	SECTION	22
DENSE	SECTION	23	.FWRD.	SECTION	24	FIELD	SECTION	25
CALCO1	SECTION	26	CALCO3	SECTION	27	.FSLO.	SECTION	28
CALCO2	SECTION	29	.EXIT.	SECTION	30	.UN05.	SECTION	31
.FRTN.	SECTION	32	.FCNV.	SECTION	33	.UN06.	SECTION	34

INPU STORAGE MAP 02/06/69 PAGE

.EFIL.	SECTION	35	E.1	SECTION	36	E.2	SECTION	37
E.3	SECTION	38	E.4	SECTION	39	CC.1	SECTION	40
CC.2	SECTION	41	CC.3	SECTION	42	CC.4	SECTION	43
SYSLOC	SECTION	44						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
781	FORMAT	14611	981	FORMAT	14613	500	FORMAT	14615
501	FORMAT	14616	999	FORMAT	14617	1000	FORMAT	14623
1001	FORMAT	14711	1002	FORMAT	14764	1003	FORMAT	15065
11	90A	16536	60	30A	15643	100	38A	15730
40	46A	15776	41	48A	16017	112	54A	16146
2000	58A	16162	2001	60A	16175	2002	FORMAT	15175
115	64A	16234	2003	69A	16315	2004	71A	16330
2005	FORMAT	15202	9	83A	16377	62	78A	16370
63	81A	16374						

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 16567.

STORAGE MAP

SUBROUTINE OUTPUT

COMMON VARIABLES

	COMMON BLOCK	EPSIN	ORIGIN	00001	LENGTH	00002		
SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
EPSIN	00000	R	PROPT	00001	R			
	COMMON BLOCK	DATA	ORIGIN	00003	LENGTH	00053		
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						
	COMMON BLOCK	HBANK1	ORIGIN	00056	LENGTH	00441		
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						
	COMMON BLOCK	CRSR	ORIGIN	00517	LENGTH	00013		
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			
	COMMON BLOCK	GAUSS	ORIGIN	00532	LENGTH	00007		
YSQUAR	00000	R	DCPDR	00001	R	DCPDP	00002	R
DFHDP	00003	R	F1T	00004	R	DNMNTR	00005	R
DEL2S	00006	R						
	COMMON BLOCK	POWLOS	ORIGIN	00541	LENGTH	00023		
COSA	00000	R	Y	00001	R	DMDR	00002	R
DMDT	00003	R	DMDP	00004	R	DMDY1	00005	R
DMDY2	00006	R	DMDY3	00007	R	DMDSI	00010	R
DMDDSI	00011	R	DMUDR	00012	R	DMUDT	00013	R
DMUDP	00014	R	DMUDY1	00015	R	DMUDY2	00016	R
DMUDY3	00017	R	DMUDSI	00020	R	EMD	00021	R
EMRAD	00022	R						
	COMMON BLOCK	GRAPH2	ORIGIN	00564	LENGTH	00024		
TITLE	00000	R						

OUTPU STORAGE MAP

COMMON BLOCK	RECI		ORIGIN	00610	LENGTH	00003		
DD	00000	R	SOA	00001	R	LB	00002	I
COMMON BLOCK	RDOTS		ORIGIN	00613	LENGTH	00002		
JUMP	00000	I	NYD1	00001	I			

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
XX	00615	R	YY	01603	R	DATE	02571	R
PLT	02575	R						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
THETA	02614	R	PHI	02615	R	DSHIFT	02616	R
VALCRT	02617	R	LL	02620	I	C2	02621	R
YOSQR	02622	R	GROUFL	02623	R	PL	02624	R

ENTRY POINTS

OUTPUT SECTION 11

SUBROUTINES CALLED

SQRT	SECTION	12	•FWRD•	SECTION	13	•FSLO•	SECTION	14
POLAR	SECTION	15	ALOG10	SECTION	16	EXP	SECTION	17
CALCO4	SECTION	18	CALCO5	SECTION	19	•FXEM•	SECTION	20
•UNU6•	SECTION	21	•FFIL•	SECTION	22	•FCNV•	SECTION	23
SYSLOC	SECTION	24						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
200	2A	03021	201	3A	03027	101	15A	03102
202	8A	03070	203	9A	03072	100	23A	03125
204	12A	03076	206	19A	03112	46	70A	03454
29	79A	03500	26	29A	03143	207	26A	03131
209	32A	03147	27	36A	03172	1007	FORMAT	03007
28	34A	03162	1002	FORMAT	02725	210	35A	03170
211	37A	03205	212	38A	03210	213	41A	03216
21	46A	03225	214	44A	03222	22	49A	03250
1003	FORMAT	03003	215	50A	03330	216	51A	03333
40	52A	03353	41	54A	03362	42	56A	03371
43	58A	03400	44	60A	03407	45	62A	03416
47	65A	03427	2040	FORMAT	02657	217	63A	03424
2041	FORMAT	02664	2042	FORMAT	02671	2043	FORMAT	02677
2044	FORMAT	02705	2045	FORMAT	02713	2046	FORMAT	02721

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00000          TRA  OUTPUT      02716          BCI  1,ST FOR     03006          BCI  1,16,7))
02625          ORG  1429        02717          BCI  1, PHI M     03007 1007.    BCI  1,( 1H1
02625 C.0      OCT  000000n00001 02720          BCI  1,IN)        03010          BCI  1,, 20X
02626 C.1      OCT  000000n00000 02721 2046.    BCI  1,(9HORD     03011          BCI  1,, 20A4
02627 C.2      OCT  000000n00000 02722          BCI  1,QT =       03012          BCI  1, )
02630 C.3      OCT  000000n00001 02723          BCI  1, E15.6     03013 1A       LDQ  YO+1
02631 C.4      OCT  206712273407 02724          BCI  1, )         03014          FMP  C.4
02632 C.5      OCT  164774272155 02725 1002.    BCI  1,(10X10     03015          STO  THETA
02633 C.6      OCT  000000n00002 02726          BCI  1,HPHASE     03016          LDQ  YO+2
02634 C.7      OCT  205517n64546 02727          BCI  1, PATH6     03017          FMP  C.4
02635 C.8      OCT  000000n00012 02730          BCI  1,X6HRAD     03020          STO  PHI
02636 C.9      OCT  000000n00000 02731          BCI  1,IUS10X     03021 2A       LDQ  F
02637 C.10     OCT  000000n00764 02732          BCI  1,10HCOL     03022          FMP  C.5
02640 C.11     OCT  157435n22421 02733          BCI  1,ATTUD      03023          XCA
02641 C.12     OCT  000000n00015 02734          BCI  1,E6X9HL     03024          FMP  YO+9
02642 C.13     OCT  000000n00024 02735          BCI  1,ONGITU     03025          CHS
02643 C.14     OCT  211454n00000 02736          BCI  1,DE7X10     03026          STO  DSHIFT
02644 C.15     OCT  204500n00000 02737          BCI  1,HARSOR     03027 3A       CLA  DMUDT
02645 C.16     OCT  207550n00000 02740          BCI  1,PTION6     03030          FDP  YO
02646 C.17     OCT  202400n00000 02741          BCI  1,X10HDO     03031          STQ  N.
02647 C.18     OCT  000000n00067 02742          BCI  1,PPLER      03032          CLA  DMUDP
02650 N.       BSS  4           02743          BCI  1,SP6X10     03033          FDP  RCT
02654 RU.      OCT  000000n00000 02744          BCI  1,HPOWER     03034          STQ  N.+1
02655          OCT  000000n00000 02745          BCI  1, LOSS/     03035          FMP  N.+1
02656 X.1      BSS  1           02746          BCI  1,10X10H     03036          STO  N.+2
02657 2040.    BCI  1,(25H0S     02747          BCI  1,GROUP      03037          LDQ  N.
02660          BCI  1,TOPPED     02750          BCI  1,PATH6X     03040          FMP  N.
02661          BCI  1, ON TE     02751          BCI  1,2HY114     03041          STO  N.+3
02662          BCI  1,ST FOR     02752          BCI  1,X2HY21     03042          LDQ  DMUDR
02663          BCI  1, RMAX)     02753          BCI  1,4X2HY3     03043          FMP  DMUDR
02664 2041.    BCI  1,(25H0S     02754          BCI  1,14X5HM     03044          FAD  N.+3
02665          BCI  1,TOPPED     02755          BCI  1,U**211     03045          FAD  N.+2
02666          BCI  1, ON TE     02756          BCI  1,X4HY**     03046          STQ  N.+2
02667          BCI  1,ST FOR     02757          BCI  1,212X10     03047 4A       TSX  SQRT,4
02670          BCI  1, RMIN)     02760          BCI  1,HEPSTE     03050          TXI  *+3,,1
02671 2042.    BCI  1,(30H0S     02761          BCI  1,IN CD/     03051          PZE  4,,LK.DR
02672          BCI  1,TOPPED     02762          BCI  1,10X8HR     03052          PZE  N.+2
02673          BCI  1, ON TE     02763          BCI  1,AY PAT     03053          STO  N.+2
02674          BCI  1,ST FOR     02764          BCI  1,H8X26H     03054          LDQ  F
02675          BCI  1, THETA     02765          BCI  1,POLARI     03055          FMP  C.7
02676          BCI  1, MAX)      02766          BCI  1,ZATION     03056          XCA
02677 2043.    BCI  1,(30H0S     02767          BCI  1, - MOD     03057          FMP  EMUS
02700          BCI  1,TOPPED     02770          BCI  1, AND A     03060          STO  N.+3
02701          BCI  1, ON TE     02771          BCI  1,RG6X6H     03061          CLA  N.+2
02702          BCI  1,ST FOR     02772          BCI  1,DEL MU     03062          FDP  N.+3
02703          BCI  1, THETA     02773          BCI  1,10X1HN     03063          STQ  VALCRT
02704          BCI  1, MIN)      02774          BCI  1,15X2HN     03064          CLA  JUMP
02705 2044.    BCI  1,(28H0S     02775          BCI  1,U14X       03065          SUB  C.6
02706          BCI  1,TOPPED     02776          BCI  1,           03066          TNZ  7A
02707          BCI  1, ON TE     02777          BCI  1,           03067 5A       NULL
02710          BCI  1,ST FOR     03000          BCI  1,11HGRO     03067 6A       TRA  15A
02711          BCI  1, PHI M     03001          BCI  1,UP DEL     03070 7A       NULL
02712          BCI  1,AX)        03002          BCI  1,AY)        03070 8A       CLA  C.3
02713 2045.    BCI  1,(28H0S     03003 1004.    BCI  1,(6X1P      03071          STO  JUMP
02714          BCI  1,TOPPED     03004          BCI  1,7E16.7     03072 9A       CLA  **
02715          BCI  1, ON TE     03005          BCI  1,/(6X7E     03073          SUB  C.8
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03074          TZE   11A
03075 10A      TRA   23A
03076 11A      NULL
03076 12A      CLA   N
03077          SUB   C.9
03100          TNZ   14A
03101 13A      TRA   OUTPUT,1
03102 14A      NULL
03102 15A      CLA   LL
03103          ADD   C.3
03104          STO   LL
03105 16A      LAC   LL,1
03106          CLA   Y0
03107 17A      STO   XX-1,1
03110          CLA   THETA
03111 18A      STO   YY-1,1
03112 19A      CLA   LL
03113          SUB   C.10
03114          TNZ   21A
03115 20A      TRA   70A
03116 21A      NULL
03116 22A      AXT   22,4
03117          PXA   0,4
03120          LAC   JUMP,4
03121          TXL   80A,4,-3
03122          XEC   *,4
03123          TRA   79A
03124          TRA   70A
03125 23A      CLA   N
03126          SUB   C.9
03127          TZE   25A
03130 24A      TRA   29A
03131 25A      NULL
03131 26A      CLA   C.11
03132          FDP   F
03133          STQ   C2
03134          CLA   C.3
03135          STO   LL
03136 27A      CLA   R0
03137          STO   XX
03140          CLA   THETA0
03141          STO   YY
03142 28A      TRA   32A
03143 29A      CLA   N
03144          SUB   C.12
03145          TZE   31A
03146 30A      TRA   36A
03147 31A      NULL
03147 32A      TSX   .FWRD.,4
03150          TXI   *+4,,2
03151          PZE   32,,LK.DR
03152          PZE   .UN06.
03153          PZE   1007.
03154 33A      TSX   .FSLO.,4
03155          TXI   *+4,,2
03156          PZE   33,,LK.DR
03157          PZE   TITLE
03160          PZE   C.13
03161          TSX   .FFIL.,4
03162 34A      TSX   .FWRD.,4
03163          TXI   *+4,,2
03164          PZE   34,,LK.DR
03165          PZE   .UN06.
03166          PZE   1002.
03167          TSX   .FFIL.,4
03170 35A      CLA   C.3
03171          STO   N
03172 36A      LDQ   Y0+5
03173          FMP   Y0+5
03174          STO   N.
03175          LDQ   Y0+4
03176          FMP   Y0+4
03177          STO   N.+1
03200          LDQ   Y0+3
03201          FMP   Y0+3
03202          FAD   N.+1
03203          FAD   N.
03204          STO   Y0SQP
03205 37A      CLA   Y0+6
03206          FDP   C.14
03207          STQ   GRODEL
03210 38A      NULL
03210 39A      TSX   POLAR,4
03211          TXI   *+2,,0
03212          PZE   39,,LK.DR
03213 40A      LDQ   RARG
03214          FMP   C.4
03215          STO   RARG
03216 41A      CLA   NPOWER
03217          SUB   C.9
03220          TZE   43A
03221 42A      TRA   46A
03222 43A      NULL
03222 44A      STZ   PL
03223          STZ   DEL2S
03224 45A      TRA   49A
03225 46A      CLS   Y0+10
03226          STO   X.1
03227 47A      TSX   EXP,4
03230          TXI   *+3,,1
03231          PZE   47,,LK.DR
03232          PZE   X.1
03233          STO   N.
03234          LDQ   EMU
03235          FMP   PROPT
03236          XCA
03237          FMP   N.
03240          STO   N.
03241 48A      TSX   ALOG10,4
03242          TXI   *+3,,1
03243          PZE   48,,LK.DR
03244          PZE   N.
03245          XCA
03246          FMP   C.15
03247          STO   PL
03250 49A      TSX   .FWRD.,4
03251          TXI   *+4,,2
03252          PZE   49,,LK.DR
03253          PZE   .UN06.
03254          PZE   1003.
03255          CLA   FINVP
03256          TSX   .FCNV.,4
03257          CLA   Y0
03260          TSX   .FCNV.,4
03261          CLA   THETA
03262          TSX   .FCNV.,4
03263          CLA   PHI
03264          TSX   .FCNV.,4
03265          CLA   Y0+8
03266          TSX   .FCNV.,4
03267          CLA   DSHIFT
03270          TSX   .FCNV.,4
03271          CLA   PL
03272          TSX   .FCNV.,4
03273          CLA   Y0+6
03274          TSX   .FCNV.,4
03275          CLA   Y0+3
03276          TSX   .FCNV.,4
03277          CLA   Y0+4
03300          TSX   .FCNV.,4
03301          CLA   Y0+5
03302          TSX   .FCNV.,4
03303          CLA   EMUS
03304          TSX   .FCNV.,4
03305          CLA   Y0SQP
03306          TSX   .FCNV.,4
03307          CLA   EPSTIN
03310          TSX   .FCNV.,4
03311          CLA   Y0+7
03312          TSX   .FCNV.,4
03313          CLA   RMOD
03314          TSX   .FCNV.,4
03315          CLA   RARG
03316          TSX   .FCNV.,4
03317          CLA   VALCRT
03320          TSX   .FCNV.,4
03321          CLA   EN
03322          TSX   .FCNV.,4
03323          CLA   GNU
03324          TSX   .FCNV.,4
03325          CLA   GRODEL
03326          TSX   .FCNV.,4
03327          TSX   .FFIL.,4
03330 50A      CLA   N
03331          ADD   C.3
03332          STO   N
03333 51A      AXT   51,4
03334          PXA   0,4
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03335 1757J  LAC  **,4        03425        STO  JUMP       03512        AXT  **,4
03336        TXL  80A,4,-12   03426 64A     TRA  15A        03513        LDI  *+2
03337        XEC  *,4         03427 65A     TSX  .FWRD.,4   03514        TRA  1,4
03340        TRA  79A         03430         TXI  *+4,,2     03515        PZE  **
03341        TRA  52A         03431         PZE  65,,LK.DR  03516        STI  *-1
03342        TRA  54A         03432         PZE  .UN06.     03517        SXA  SYSLOC,4
03343        TRA  56A         03433         PZE  2046.      03520        SXA  LK.DR,4
03344        TRA  58A         03434         CLA  YD         03521        SXA  *-7,4
03345        TRA  60A         03435         TSX  .FCNV.,4   03522        SXA  *-9,1
03346        TRA  62A         03436         TSX  .FFIL.,4   03523        CLA  3,4
03347        TRA  79A         03437         CLA  THETA      03524        STA  9A
03350        TRA  65A         03440         FSB  C.16       03525        STA  1757J
03351        TRA  79A         03441         STO  N.         03526        TRA  1A
03352        TRA  79A         03442         CLA  N.
03353 52A    TSX  .FWRD.,4    03443         SSP
03354        TXI  *+4,,2      03444         SUB  C.17
03355        PZE  52,,LK.DR   03445         TZE  68A
03356        PZE  .UN06.      03446         TPL  68A
03357        PZE  2040.       03447 66A     NULL
03360        TSX  .FFIL.,4    03447 67A     TRA  15A
03361 53A    TRA  63A         03450 68A     CLA  NYD1
03362 54A    TSX  .FWRD.,4    03451         ADD  C.3
03363        TXI  *+4,,2      03452         STO  NYD1
03364        PZE  54,,LK.DR   03453 69A     TRA  15A
03365        PZE  .UN06.      03454 70A     CLA  NPLOT
03366        PZE  2041.       03455         SUB  C.9
03367        TSX  .FFIL.,4    03456         TNZ  72A
03370 55A    TRA  63A         03457 71A     TRA  OUTPUT+1
03371 56A    TSX  .FWRD.,4    03460 72A     NULL
03372        TXI  *+4,,2      03460 73A     TSX  CALC04,4
03373        PZE  56,,LK.DR   03461         TXI  *+5,,3
03374        PZE  .UN06.      03462         PZE  73,,LK.DR
03375        PZE  2042.       03463         PZE  LB
03376        TSX  .FFIL.,4    03464         PZE  DD
03377 57A    TRA  63A         03465         PZE  SOA
03400 58A    TSX  .FWRD.,4    03466 74A     NULL
03401        TXI  *+4,,2      03466 75A     TSX  CALC05,4
03402        PZE  58,,LK.DR   03467         TXI  *+5,,3
03403        PZE  .UN06.      03470         PZE  75,,LK.DR
03404        PZE  2043.       03471         PZE  LL
03405        TSX  .FFIL.,4    03472         PZE  XX
03406 59A    TRA  63A         03473         PZE  YY
03407 60A    TSX  .FWRD.,4    03474 76A     CLA  C.3
03410        TXI  *+4,,2      03475         STO  JUMP
03411        PZE  60,,LK.DR   03476 77A     STZ  LL
03412        PZE  .UN06.      03477 78A     STZ  LB
03413        PZE  2044.       03500 79A     TRA  OUTPUT+1
03414        TSX  .FFIL.,4    03501 80A     STA  **+3
03415 61A    TRA  63A         03502         TSX  .FXEM.,4
03416 62A    TSX  .FWRD.,4    03503         TXI  **+3,,1
03417        TXI  *+4,,2      03504         PZE  80,,LK.DR
03420        PZE  62,,LK.DR   03505         PZE  C.18
03421        PZE  .UN06.      03506 LK.,R   PZE  **
03422        PZE  2045.       03507         BCI  1,OUTPU
03423        TSX  .FFIL.,4    03510 OUTPUT  TXI  **+6,,**
03424 63A    CLA  C.6         03511         AXT  **,1
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THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 03527.

STORAGE MAP

BLOCK DATA

COMMON VARIABLES

	COMMON BLOCK	GRAPH0	ORIGIN	00000	LENGTH	00005	
SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
XMAX0	00000	R	XMIN0	00001	R	YMAX0	00002	R
YMIN0	00003	R	PLT	00004	R			
	COMMON BLOCK	GRAPH1	ORIGIN	00005	LENGTH	00005	
XMAX1	00000	R	XMIN1	00001	R	YMAX1	00002	R
YMIN1	00003	R	DATE	00004	R			
	COMMON BLOCK	CONST	ORIGIN	00012	LENGTH	00007	
ORDER	00000	R	EUBAR	00001	R	ELBAR	00002	R
YCLOW	00003	R	HMAXT	00004	R	HMINT	00005	R
KD	00006	I						

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00021.

STORAGE MAP

SUBROUTINE PRAM

ENTRY POINTS

PRAM SECTION 2

SUBROUTINES CALLED

SYSLOC SECTION 3

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00073.

SUBROUTINE CALCO4

COMMON VARIABLES

COMMON BLOCK	GRAPH0		ORIGIN	00001		LENGTH	00023	
SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
XMAX0	00000	R	XMIN0	00001	R	YMAX0	00002	R
YMIN0	00003	R	PLT	00004	R			
COMMON BLOCK	GRAPH1		ORIGIN	00024		LENGTH	00011	
XMAX1	00000	R	XMIN1	00001	R	YMAX1	00002	R
YMIN1	00003	R	DATE	00004	R			

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
PLDAT	00035	R						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MODE	00605	I	LVAL	00606	I	KVAL	00607	I
JVAL	00610	I	AR	00611	R	IC	00612	I
PHI	00613	R						

ENTRY POINTS

CALCO4	SECTION	4	CALCO5	SECTION	5	CALCO1	SECTION	6
CALCO2	SECTION	7	CALCO3	SECTION	8			

SUBROUTINES CALLED

PRAM	SECTION	9	AXIS	SECTION	10	SYMBOL	SECTION	11
NUMBER	SECTION	12	LINE	SECTION	13	PLOT	SECTION	14
SIN	SECTION	15	COS	SECTION	16	PLOTS	SECTION	17
CC.1	SECTION	18	CC.2	SECTION	19	CC.3	SECTION	20
CC.4	SECTION	21	SYSLOC	SECTION	22			

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
12	70A	01427	10	65A	01404	11	68A	01416
600	85A	01475	300	111A	01626			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 02137.

STORAGE MAP

SUBROUTINE DENSE

COMMON VARIABLES

COMMON BLOCK RECT ORIGIN 00001 LENGTH 13565

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
DU	00000	R	SQA	05672	R	LB	13564	I

COMMON BLOCK DATA ORIGIN 13566 LENGTH 00054

RMAX	00000	R	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R

COMMON BLOCK HBANK1 ORIGIN 13642 LENGTH 00441

MORDER	00000	I	YO	00007	R	YD	00022	R
SCR	00035	R						

COMMON BLOCK RBLK1 ORIGIN 14303 LENGTH 00005

STZM5	00000	R	HPRIME	00001	R	PKDELN	00002	R
AMBDL	00003	R	HU	00004	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RPERD	14310	R	RAD	14311	R	DISMAX	14312	R
R	14313	R	TH	14314	R	AMPDA	14315	R
SNLAM1	14316	R	SNLAM2	14317	R	SNLAM3	14320	R
SNTH1	14321	R	SNTH2	14322	R	SNTH3	14323	R
CSTH1	14324	R	TNTH1	14325	R	TNTH2	14326	R
STSL	14327	R	ZM1	14330	R	ZM2	14331	R
ZM3	14332	R	ZM4	14333	R	ZM5	14334	R
H	14335	R	DIFF	14336	R	TWO	14337	R
DTHETA	14340	R	THETA1	14341	R	TNTH11	14342	R
DIS	14343	R	W1	14344	R	T17	14345	R
ENF	14346	R	DENFDR	14347	R	ZX	14350	R
DZXDR	14351	R	ENXR	14352	R	ENX	14353	R
DENXDR	14354	R	DENXDT	14355	R	FACTOR	14356	R
PKFRAC	14357	R	FRACTN	14360	R	DFDN	14361	R
T31	14362	R	CY02	14363	R	AY2	14364	R
COAM	14365	R	SIAMS	14366	R	SL	14367	R
ST	14370	R						

ENTRY POINTS

DENSE SECTION 6

SUBROUTINES CALLED

SIN	SECTION	7	COS	SECTION	8	TAN	SECTION	9
SQRT	SECTION	10	EXP	SECTION	11	ALOG	SECTION	12
SYSLOC	SECTION	13						

STORAGE MAP

FEN IFN CORRESPONDENCE

FEN	IFN	LOCATION	FEN	IFN	LOCATION	FEN	IFN	LOCATION
40	21A	15117	41	23A	15161	118	28A	15315
3	FORMAT	14437	12	46A	15452			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 15471.

SUBROUTINE FIELD

COMMON VARIABLES

	COMMON BLOCK	EXFLD		ORIGIN	00001	LENGTH	00006	
SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
D2CY1R	00000	R	D2SY1R	00001	R	D2CY2T	00002	R
D2SY2T	00003	R	D2CY3P	00004	R	D2SY3P	00005	R
	COMMON BLOCK	DATA		ORIGIN	00007	LENGTH	00054	
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	A0	00010	R
B0	00011	R	P0	00012	R	THETA0	00013	R
PHI0	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NVAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I	NTEST	00053	I			
	COMMON BLOCK	HBANK1		ORIGIN	00063	LENGTH	00441	
MORDER	00000	I	NOHALF	00001	I	NOPOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	Y0	00007	R	Y0	00022	R
MA	00035	I						
	COMMON BLOCK	GAUSS		ORIGIN	00524	LENGTH	00007	
YSQUAR	00000	R	DCPUP	00001	R	DCPDP	00002	R
DFHDP	00003	R	F1T	00004	R	DNMNTR	00005	R
DEL2S	00006	R						
	COMMON BLOCK	CRSR		ORIGIN	00533	LENGTH	00013	
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
F2T	00546	R	RTF1T	00547	R	Y04S	00550	R
Y05C	00551	R	F1P	00552	R			

ENTRY POINTS

FIEL STORAGE MAP

SUBROUTINES CALLED

SQRT SECTION 8 SYSLOC SECTION 9

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
100	1A	00570	101	2A	00603	102	4A	00610
103	5A	00621	104	6A	00633	105	7A	00634
106	8A	00637	107	9A	00651	108	13A	00766

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 01021.

SUBROUTINE POWERL

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00053

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	A0	00010	R
B0	00011	R	R0	00012	R	THETA0	00013	R
PHI0	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						

COMMON BLOCK HBANK1 ORIGIN 00054 LENGTH 00441

MORDER	00000	I	NOHALF	00001	I	NONOUB	00002	I
HBANK	00003	R	NOEW	00004	I	FINVP	00005	R
FINVPI	00006	R	Y0	00007	R	Y0	00022	R
MA	00035	I	YP	00007	R			

COMMON BLOCK POWLOS ORIGIN 00515 LENGTH 00023

COSA	00000	R	Y	00001	R	DMDR	00002	R
DMDT	00003	R	DMDP	00004	R	DMDY1	00005	R
DMDY2	00006	R	DMDY3	00007	R	DMDST	00010	R
DMDUSI	00011	R	DMUDR	00012	R	DMUDT	00013	R
DMUDP	00014	R	DMUDY1	00015	R	DMUDY2	00016	R
DMUDY3	00017	R	DMUDSI	00020	R	EMD	00021	R
EMRAD	00022	R						

COMMON BLOCK CRSR ORIGIN 00540 LENGTH 00013

C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	EM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

COMMON BLOCK GAUSS ORIGIN 00553 LENGTH 00007

YSQUAR	00000	R	DCPDR	00001	R	DCPDP	00002	R
DFHDP	00003	R	F1T	00004	R	DNMNTR	00005	R
DEL2S	00006	R						

COMMON BLOCK EXFLD ORIGIN 00562 LENGTH 00006

D2CY1R	00000	R	D2SY1R	00001	R	D2CY2T	00002	R
D2SY2T	00003	R	D2CY3P	00004	R	D2SY3P	00005	R

DIMENSIONED PROGRAM VARIABLES

STORAGE MAP

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
A	00570	R	B	00601	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
Y2	00612	R	TERMC1	00613	R	COSPS2	00614	R
AA2	00615	R	YC	00616	R	AA2C1	00617	R
ENDA2C	00620	R	XTERM	00621	R	EMPAD2	00622	R
FMCSP2	00623	R	F2C	00624	R	TO	00625	R
PO	00626	R	SIPO	00627	R	COPO	00630	R
SITO	00631	R	COTO	00632	R	RO2	00633	R
COP	00634	R	SIP	00635	R	SIPMP	00636	R
COPMP	00637	R	RP2	00640	R	RP	00641	R
COTP	00642	R	SITP	00643	R	COPP	00644	R
DRPDR	00645	R	DRPDT	00646	R	DRPDP	00647	R
DRDRP	00650	R	DTDRP	00651	R	DPDRP	00652	R
D2MY1R	00653	R	D2MY2T	00654	R	D2MY3P	00655	R
D2AY1R	00656	R	D2AY2T	00657	R	D2AY3P	00660	R
DADY1	00661	R	DADY2	00662	R	DADY3	00663	R
DADR	00664	R	DADT	00665	R	DADP	00666	R
DBDR	00667	R	DBDT	00670	R	DBDP	00671	R
DBDSI	00672	R	D2MDSR	00673	R	D2MDST	00674	R
D2MDSP	00675	R	D2UDSR	00676	R	D2UDST	00677	R
D2UDSP	00700	R	D2UY1R	00701	R	D2UY2T	00702	R
D2UY3P	00703	R	YPEMDU	00704	R	YP2MDU	00705	R
YP3MDU	00706	R	XTEM2	00707	R	XTEM	00710	R
DMUDRP	00711	R	DUDSRP	00712	R	DUY1RP	00713	R
DUY2RP	00714	R	DUY3RP	00715	R	RDOTP	00716	R

ENTRY POINTS

POWERL SECTION 8

SUBROUTINES CALLED

SIN	SECTION	9	COS	SECTION	10	SQRT	SECTION	11
MINV	SECTION	12	SYSLOC	SECTION	13			

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
500	1A	00737	501	2A	01002	502	3A	01006
79	11A	01047	80	5A	01010	503	10A	01045
504	16A	01101	2	17A	01126	10	19A	01141
505	21A	01153	506	22A	01167	507	23A	01224
508	24A	01235	509	25A	01323	510	26A	01330
511	29A	01342	512	30A	01344	513	31A	01442
514	32A	01500	515	33A	01640	516	34A	01720
517	35A	02012	518	36A	02030	519	37A	02041
520	38A	02044	521	39A	02140	522	40A	02176
523	41A	02527	524	42A	02564	525	43A	02576

POWER STORAGE MAP

526	44A	02603	527	46A	02650	528	47A	02653
529	48A	02671	530	49A	03010			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 03032.

STORAGE MAP

SUBROUTINE FORCE

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00053

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THFTAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	E2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						

COMMON BLOCK HBANK1 ORIGIN 00054 LENGTH 00441

MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
YNRMLZ	00515	R						

ENTRY POINTS

FORCE SECTION 4

SUBROUTINES CALLED

SYSLOC SECTION 5

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
100	1A	00522	101	2A	00525	102	3A	00533

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00553.

COL 02/06/69 PAGE

STORAGE MAP

SUBROUTINE COLL

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
A	00001	R	B	00007	R	C	00015	R
D	00020	R						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
X	00023	R	COEFF	00024	R	YFAC	00025	R
S	00026	R	E	00027	R			

ENTRY POINTS

COLL SECTION 2

SUBROUTINES CALLED

.XPJ. SECTION 3 COS SECTION 4 SIN SECTION 5
SYSLOC SECTION 6

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
4	2A	00056	5	4A	00062	6	7A	00076
9	5A	00067	65	9A	00125	7	11A	00131
8	16A	00223	75	14A	00151	85	17A	00226

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00276.

CST STORAGE MAP

SUBROUTINE CSINT

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
A0	00001	R	A2	00005	R	A4	00011	R
A6	00015	R	QP	00021	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
X	00025	R	M	00026	I	MM	00027	I
POFX	00030	R	QOFX	00031	R	POLD	00032	R
QOLD	00033	R	SGN	00034	R	FRROR	00035	R
N	00036	I	NN	00037	I	NNN	00040	I
BN	00041	R	CN	00042	R	P	00043	R
PP	00044	R	PPP	00045	R	Q	00046	R
AN	00047	R	TERM	00050	R	XSQ	00051	R
REC	00052	R	CC	00053	R	SS	00054	R

ENTRY POINTS

CSINT SECTION 2

SUBROUTINES CALLED

TOR	SECTION	3	.XP3.	SECTION	4	COS	SECTION	5
SIN	SECTION	6	.FWRD.	SECTION	7	EXIT	SECTION	8
ALOG	SECTION	9	.UN06.	SECTION	10	.FFIL.	SECTION	11
.FCNV.	SECTION	12	E.1	SECTION	13	E.2	SECTION	14
E.3	SECTION	15	E.4	SECTION	16	CC.1	SECTION	17
CC.2	SECTION	18	CC.3	SECTION	19	CC.4	SECTION	20
SYSLOC	SECTION	21						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
5	2A	00120	6	3A	00122	7	4A	00124
400	44A	00354	4	6A	00130	20	7A	00140
40	34A	00305	21	13A	00170	30	23A	00235
22	15A	00173	24	18A	00214	25	20A	00230
26	22A	00233	35	31A	00277	31	25A	00240
33	28A	00261	34	30A	00275	36	33A	00303
41	37A	00311	42	40A	00333	500	80A	00664
401	46A	00357	402	48A	00370	409	51A	00374
1000	FORMAT	00107	403	49A	00371	404	50A	00373
410	53A	00400	5002	84A	00672	411	54A	00420
55	56A	00444	420	57A	00446	440	77A	00662
421	61A	00467	430	68A	00564	422	63A	00472
425	67A	00562	424	65A	00556	435	75A	00657
431	70A	00567	434	74A	00655	433	72A	00651

CST STORAGE MAP

5001	82A	00667	5003	83A	00671	5005	85A	00672
5006	86A	00700	5007	90A	00701	5008	98A	00716
5009	99A	00730	5010	102A	00742	5011	103A	00762

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 01024.

STORAGE MAP

SUBROUTINE POLAR

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00054

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I	NTEST	00053	I			

COMMON BLOCK HBANK1 ORIGIN 00055 LENGTH 00441

MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						

COMMON BLOCK CRSR ORIGIN 00516 LENGTH 00013

C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
R	00531	C	XMZ	00533	C	Y	00535	R
YL	00536	R	YT	00537	R	YL2	00540	R
YT2	00541	R	YT4	00542	R			

ENTRY POINTS

POLAR	SECTION	5

SUBROUTINES CALLED

CSQRT	SECTION	6	.CFDP.	SECTION	7	.CFMP.	SECTION	8
CABS	SECTION	9	ATAN2	SECTION	10	E.1	SECTION	11
E.2	SECTION	12	E.3	SECTION	13	E.4	SECTION	14
SYSLOC	SECTION	15						

STORAGE MAP

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
101	2A	00616	102	4A	00717	103	6A	00724

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00753.

TQ STORAGE MAP

FUNCTION TQR TYPE R

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
F.0000	00001	R	X	00002	R	TEMP	00003	R
NOR	00004	I						

ENTRY POINTS

TQR SECTION 2

SUBROUTINES CALLED

.XP1.	SECTION	3	EXP	SECTION	4	SQRT	SECTION	5
F.1	SECTION	6	F.2	SECTION	7	F.3	SECTION	8
F.4	SECTION	9	CC.1	SECTION	10	CC.2	SECTION	11
CC.3	SECTION	12	CC.4	SECTION	13	SYSLOC	SECTION	14

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00124.

STORAGE MAP

SUBROUTINE MINV

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
IPIV	00001	I						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
I	00004	I	NMI	00005	I	IMAX	00006	I
IPI	00007	I	J	00010	I	TPJ	00011	I
IPMAX	00012	I	TEMP	00013	R	TPIVI	00014	I
IPN	00015	I	ICOMP	00016	I	TPCO	00017	I
ICOPI	00020	I						

ENTRY POINTS

MINV	SECTION	2

SUBROUTINES CALLED

E.1	SECTION	3	E.2	SECTION	4	E.3	SECTION	5
E.4	SECTION	6	CC.1	SECTION	7	CC.2	SECTION	8
CC.3	SECTION	9	CC.4	SECTION	10	SYSLOC	SECTION	11

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
1	5A	00037	2	52A	00257	5	25A	00140
6	24A	00136	7	50A	00255	8	44A	00245
9	80A	00351	10	78A	00347	11	72A	00337
12	114A	00472	13	106A	00450	14	91A	00412
15	104A	00446	16	98A	00436	17	109A	00464
30	124A	00517						

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00636.

$IBMAP SMK2

SMK2 02/17/69 PAGE
7094 RELMOD ASSEMBLY.

$IBLDR SMK2 02/17/69 SMK20000

ASSEMBLED TEXT.

```
                $TEXT  SMK2                                                    SMK20001
                                *7044 FORTRAN IV SET UP ROUTINE FOR JP-MARK                    SMK00010
                                *       PROGRAMMER-R.GOODELL                                   SMK00020
                                *       MAP-7044                                               SMK00040
                                *  CALL SMARK(KIND,N,HBANK-3,NRTN,NTRG,EU,EL,HMX,HMN,YL,       SMK00050
                                *  ETC  LV1,TV1,                                               SMK00060
                                *  ETC  LV2,TV2,                                               SMK00070
                                *  ETC  UP TO TEN TRIGGERS                                     SMK00080
                00000           ENTRY SMARK                                                    SMK00090
                00031   NOFIRG EQU   25          NUMBER OF TRIGGERS
                00000    SMARK SAVE  1,2,4                                                     SMK00100

BINARY CARD (NOT PUNCHED)
      00000  1 00000 0 00005  10001
      00001  0774 00 2 00000  10000
      00002  0774 00 1 00000  10000
      00003  0774 00 4 00000  10000
      00004  0020 00 4 00001  10000
      00005  0634 00 4 12000  10011
      00006  0634 00 4 00355  10001
      00007  0634 00 4 00003  10001
      00010  0634 00 1 00002  10001
      00011  0634 00 2 00001  10001
      00012  1 77776 4 01001  10011        TXI   *+1,4,-2                                     SMK00110
      00013  4500 60 4 00001  10000        CAL*  1,4                                          SMK00120
      00014  0767 00 0 00017  10000        ALS   15                                           SMK00130
      00015  4501 00 0 00351  10001        ORA   ADER        DER1,0,DER2                      SMK00140
      00016  0602 00 0 00102  10001        SLW   CMARK+2,                                     SMK00150
      00017  0500 00 4 00003  10000        CLA   3,4                                          SMK00160
      00020  0400 00 0 00357  10001        ADD   =3                                           SMK00170
      00021  0621 00 0 00101  10001        STA   CMARK+1                                      SMK00180
      00022  0400 00 0 00360  10001        ADD   =1                                           SMK00190

BINARY CARD (NOT PUNCHED)
      00023  0621 00 0 00033  10001        STA   STON                                         SMK00200
      00024  0400 00 0 00360  10001        ADD   =1                                           SMK00210
      00025  0621 00 0 00352  10001        STA   AINV                                         SMK00220
      00026  0400 00 0 00360  10001        ADD   =1                                           SMK00230
      00027  0621 00 0 01001  10011        STA   *+1                                          SMK00240
      00030  0600 00 0 00000  10000        STZ   **                                           SMK00250
      00031  0500 60 4 00002  10000        CLA*  2,4                                          SMK00260
      00032  0767 00 0 00042  10000        ALS   18                                           SMK00270
      00033  0622 00 0 00000  10000  STON  STD   **                                           SMK00280
      00034  0500 00 4 00004  10000        CLA   4,4                                          SMK00290
      00035  0621 00 0 00353  10001        STA   NRTN                                         SMK00300
      00036  0500 00 4 00005  10000        CLA   5,4                                          SMK00310
      00037  0621 00 0 00354  10001        STA   NTRG                                         SMK00320
      00040  0500 60 4 00006  10000        CLA*  6,4                                          SMK00330
      00041  0601 00 0 13000  10011        STO   EUBAR                                        SMK00340
                                *  EXTERN  EUBAR                                           SMK00350
      00042  0500 60 4 00007  10000        CLA*  7,4                                          SMK00360
      00043  0601 00 0 14000  10011        STO   ELBAR                                        SMK00370
                                *  EXTERN  ELBAR                                           SMK00380
      00044  0500 60 4 00010  10000        CLA*  8,4                                          SMK00390
      00045  0601 00 0 15000  10011        STO   HMAXT                                        SMK00400
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                                    *       EXTERN  HMAXT                                   SMK00410

BINARY CARD (NOT PUNCHED)
          00046  0500 60 4 00011  10000             CLA*    9,4                             SMK00420
          00047  0601 00 0 16000  10011             STO     HMINT                           SMK00430
                                    *       EXTERN  HMINT                                   SMK00440
          00050  0500 60 4 00012  10000             CLA*    10,4                            SMK00450
          00051  0601 00 0 17000  10011             STO     YCLOW                           SMK00460
                                    *       EXTERN  YCLOW                                   SMK00470
          00052  0600 00 0 20000  10011             STZ     RGERR                           SMK00480
                                    *       EXTERN  RGERR                                   SMK00490
          00053  0774 00 1 00000  10000             AXT     0,1                             SMK00500
          00054  0500 00 4 00013  10000  STRG       CLA     11,4                            SMK00510
          00055  4320 00 0 00361  10001             ANA     =0777777000000                  SMK00520
          00056  4100 00 0 00072  10001             TNZ     ENTRG                           SMK00530
          00057  0500 00 4 00013  10000             CLA     11,4                            SMK00540
          00060  0340 00 0 00352  10001             CAS     AINV            INDEPENDENT VARIABLE SMK00550
          00061  0020 00 0 01002  10011             TRA     *+2                             SMK00560
          00062  0500 00 0 00362  10001             CLA     =0                              SMK00570
          00063  0767 00 0 00022  10000             ALS     18                              SMK00580
          00064  0622 00 1 00104  10001             STO     TRG,1                           SMK00590
          00065  0500 00 4 00014  10000             CLA     12,4                            SMK00630
          00066  0621 00 1 00105  10001             STA     TRG+1,1                         SMK00640
          00067  1 77776 1 01001  10011             TXI     *+1,1,-2                        SMK00650
          00070  7 77716 1 00100  10001             TXL     CMARK,1,-2*NOFTRG

BINARY CARD (NOT PUNCHED)
          00071  1 77776 4 00054  10001             TXI     STRG,4,-2
          00072  0500 00 1 00104  10001  ENTRG      CLA     TRG,1           TURN OFF REMAINING TRIGGERS SMK00670
          00073  0760 00 0 00003  10000             SSP                                     SMK00680
          00074  0760 00 0 00002  10000             CHS                                     SMK00690
          00075  0601 00 1 00104  10001             STO     TRG,1                           SMK00700
          00076  1 77776 1 01001  10011             TXI     *+1,1,-2                        SMK00710
          00077  3 77716 1 00072  10001             TXH     ENTRG,1,-2*NOFTRG               SMK00720
          00100  0074 00 4 21000  10011  CMARK      TSX     MARK,4                          SMK00740
                                    *       EXTERN  MARK                                    SMK00750
          00101  0 00167 0 00000  10100             PZE     **,0,FOS                        SMK00760
          00102  0 00173 0 00171  10101             PZE     DER1,,DER2                      SMK00770
          00103  0020 00 0 00344  10001             TRA     EMARK                           SMK00780
          00104  0 00000 0 00260  10001  IRG        PZE     IRG1                            SMK00790
          00105  0 00000 0 00000  10000             PZE                                     SMK00800
          00106  0 00000 0 00262  10001             PZE     IRG2                            SMK00810
          00107  0 00000 0 00000  10000             PZE                                     SMK00820
          00110  0 00000 0 00264  10001             PZE     IRG3                            SMK00830
          00111  0 00000 0 00000  10000             PZE                                     SMK00840
          00112  0 00000 0 00266  10001             PZE     IRG4                            SMK00850
          00113  0 00000 0 00000  10000             PZE                                     SMK00860

BINARY CARD (NOT PUNCHED)
          00114  0 00000 0 00270  10001             PZE     IRG5                            SMK00870
          00115  0 00000 0 00000  10000             PZE                                     SMK00880
          00116  0 00000 0 00272  10001             PZE     IRG6                            SMK00890
          00117  0 00000 0 00000  10000             PZE                                     SMK00900
          00120  0 00000 0 00274  10001             PZE     IRG7                            SMK00910
          00121  0 00000 0 00000  10000             PZE                                     SMK00920
          00122  0 00000 0 00276  10001             PZE     IRG8                            SMK00930
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00123  0 00000 0 00000  10000        PZE                                SMK00940
00124  0 00000 0 00300  10001        PZE    TRG9                        SMK00950
00125  0 00000 0 00000  10000        PZE                                SMK00960
00126  0 00000 0 00302  10001        PZE    TRG10                       SMK00970
00127  0 00000 0 00000  10000        PZE                                SMK00980
00130  0 00000 0 00304  10001        PZE    TRG11
00131  0 00000 0 00000  10000        PZE
00132  0 00000 0 00306  10001        PZE    TRG12
00133  0 00000 0 00000  10000        PZE
00134  0 00000 0 00310  10001        PZE    TRG13
00135  0 00000 0 00000  10000        PZE
00136  0 00000 0 00312  10001        PZE    TRG14

BINARY CARD (NOT PUNCHED)
00137  0 00000 0 00000  10000        PZE
00140  0 00000 0 00314  10001        PZE    TRG15
00141  0 00000 0 00000  10000        PZE
00142  0 00000 0 00316  10001        PZE    TRG16
00143  0 00000 0 00000  10000        PZE
00144  0 00000 0 00320  10001        PZE    TRG17
00145  0 00000 0 00000  10000        PZE
00146  0 00000 0 00322  10001        PZE    TRG18
00147  0 00000 0 00000  10000        PZE
00150  0 00000 0 00324  10001        PZE    TRG19
00151  0 00000 0 00000  10000        PZE
00152  0 00000 0 00326  10001        PZE    TRG20
00153  0 00000 0 00000  10000        PZE
00154  0 00000 0 00330  10001        PZE    TRG21
00155  0 00000 0 00000  10000        PZE
00156  0 00000 0 00332  10001        PZE    TRG22
00157  0 00000 0 00000  10000        PZE
00160  0 00000 0 00334  10001        PZE    TRG23
00161  0 00000 0 00000  10000        PZE

BINARY CARD (NOT PUNCHED)
00162  0 00000 0 00336  10001        PZE    TRG24
00163  0 00000 0 00000  10000        PZE
00164  0 00000 0 00340  10001        PZE    TRG25
00165  0 00000 0 00000  10000        PZE
00166  0 00000 0 00000  10000        PZE                                SMK00990
00167  0500 00 0 00360  10001  EOS   CLA    =1                          SMK01000
00170  0020 00 0 00176  10001        TRA    EXIT                        SMK01010
00171  0500 00 0 00363  10001  DER1  CLA    =2                          SMK01020
00172  0020 00 0 00176  10001        TRA    EXIT                        SMK01030
00173  0500 00 0 00357  10001  DER2  CLA    =3                          SMK01040
00174  0020 00 0 00176  10001        TRA    EXIT                        SMK01050
00175  0500 00 0 00364  10001  GTRG  CLA    =4                          SMK01060
00176  0634 00 4 00350  10001  EXIT  SXA    IX4,4                       SMK01070
00177  0634 00 1 00346  10001        SXA    IX1,1                       SMK01080
00200  0634 00 2 00347  10001        SXA    IX2,2                       SMK01090
00201  0601 60 0 00353  10001        STO*   NRTN                        SMK01100
                00202                RETURN SMARK                       SMK01110
00203  0774 00 0 00000  10000  TRA14 AXT    0,0                         SMK01120
00204  0534 00 4 00350  10001        LXA    IX4,4                       SMK01130

BINARY CARD (NOT PUNCHED)
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```
00205  0534 00 1 00346  10001          LXA    IX1,1                    SMK01140
00206  0534 00 2 00347  10001          LXA    IX2,2                    SMK01150
00207  0020 00 4 00001  10000          TRA    1,4                      SMK01160
                00203                  ENTRY  TRA14                    SMK01170
00210  0774 00 0 00000  10000  TRA24    AXT    0,0                      SMK01180
00211  0534 00 4 00350  10001          LXA    IX4,4                    SMK01190
00212  0534 00 1 00346  10001          LXA    IX1,1                    SMK01191
00213  0534 00 2 00347  10001          LXA    IX2,2                    SMK01192
00214  0020 00 4 00002  10000          TRA    2,4                      SMK01200
                00210                  ENTRY  TRA24                    SMK01210
                              *        CALL   ON(NOTRG)                SMK01220
                00215                  ENTRY  ON                       SMK01230
                00215           ON     SAVE   1,2,4                    SMK01240
00215  1 00000 0 00222  10001
00216  0774 00 2 00000  10000
00217  0774 00 1 00000  10000
00220  0774 00 4 00000  10000
00221  0020 00 4 00001  10000
00222  0634 00 4 12000  10011
00223  0634 00 4 00355  10001
00224  0634 00 4 00220  10001
00225  0634 00 1 00217  10001
00226  0634 00 2 00216  10001
00227  0500 00 4 00003  10000          CLA*   3,4                      SMK01250

BINARY CARD (NOT PUNCHED)
00230  0767 00 0 00001  10000          ALS    1                        SMK01260
00231  0737 00 1 00000  10000          PAC    **,1                     SMK01270
00232  0500 00 1 00102  10001          CLA    TRG-2,1                  SMK01280
00233  0760 00 0 00003  10000          SSP                             SMK01290
00234  0601 00 1 00102  10001          STO    TRG-2,1                  SMK01300
                00235                  RETURN ON                       SMK01310
                              *        CALL   OFF(NOTRG)               SMK01320
                00236                  ENTRY  OFF                      SMK01330
                00236           OFF    SAVE   1,2,4                    SMK01340
00236  1 00000 0 00243  10001
00237  0774 00 2 00000  10000
00240  0774 00 1 00000  10000
00241  0774 00 4 00000  10000
00242  0020 00 4 00001  10000
00243  0634 00 4 12000  10011
00244  0634 00 4 00355  10001
00245  0634 00 4 00241  10001
00246  0634 00 1 00240  10001
00247  0634 00 2 00237  10001
00250  0500 00 4 00003  10000          CLA*   3,4                      SMK01350
00251  0767 00 0 00001  10000          ALS    1                        SMK01360
00252  0737 00 1 00000  10000          PAC    **,1                     SMK01370

BINARY CARD (NOT PUNCHED)
00253  0500 00 1 00102  10001          CLA    TRG-2,1                  SMK01380
00254  0760 00 0 00003  10000          SSP                             SMK01390
00255  0760 00 0 00002  10000          CHS                             SMK01400
00256  0601 00 1 00102  10001          STO    TRG-2,1                  SMK01410
                00257                  RETURN OFF                      SMK01420
00260  0500 00 0 00300  10001  TRG1    CLA    =1                       SMK01430
```

```
00261  0020 00 0 00341  10001          IRA     ETRG                SMK01440
00262  0500 00 0 00363  10001  IRG2    CLA     =2                  SMK01450
00263  0020 00 0 00341  10001          IRA     ETRG                SMK01460
00264  0500 00 0 00357  10001  IRG3    CLA     =3                  SMK01470
00265  0020 00 0 00341  10001          IRA     ETRG                SMK01480
00266  0500 00 0 00364  10001  IRG4    CLA     =4                  SMK01490
00267  0020 00 0 00341  10001          IRA     ETRG                SMK01500
00270  0500 00 0 00365  10001  IRG5    CLA     =5                  SMK01510
00271  0020 00 0 00341  10001          IRA     ETRG                SMK01520
00272  0500 00 0 00366  10001  IRG6    CLA     =6                  SMK01530
00273  0020 00 0 00341  10001          IRA     ETRG                SMK01540
00274  0500 00 0 00367  10001  IRG7    CLA     =7                  SMK01550
00275  0020 00 0 00341  10001          IRA     ETRG                SMK01560

BINARY CARD (NOT PUNCHED)
00276  0500 00 0 00370  10001  IRG8    CLA     =8                  SMK01570
00277  0020 00 0 00341  10001          IRA     ETRG                SMK01580
00300  0500 00 0 00371  10001  IRG9    CLA     =9                  SMK01590
00301  0020 00 0 00341  10001          IRA     ETRG                SMK01600
00302  0500 00 0 00372  10001  IRG10   CLA     =10                 SMK01610
00303  0020 00 0 00341  10001          IRA     ETRG
00304  0500 00 0 00373  10001  IRG11   CLA     =11
00305  0020 00 0 00341  10001          IRA     ETRG
00306  0500 00 0 00374  10001  IRG12   CLA     =12
00307  0020 00 0 00341  10001          IRA     ETRG
00310  0500 00 0 00375  10001  IRG13   CLA     =13
00311  0020 00 0 00341  10001          IRA     ETRG
00312  0500 00 0 00376  10001  IRG14   CLA     =14
00313  0020 00 0 00341  10001          IRA     ETRG
00314  0500 00 0 00377  10001  IRG15   CLA     =15
00315  0020 00 0 00341  10001          IRA     ETRG
00316  0500 00 0 00400  10001  IRG16   CLA     =16
00317  0020 00 0 00341  10001          IRA     ETRG
00320  0500 00 0 00401  10001  IRG17   CLA     =17

BINARY CARD (NOT PUNCHED)
00321  0020 00 0 00341  10001          IRA     ETRG
00322  0500 00 0 00402  10001  IRG18   CLA     =18
00323  0020 00 0 00341  10001          IRA     ETRG
00324  0500 00 0 00403  10001  IRG19   CLA     =19
00325  0020 00 0 00341  10001          IRA     ETRG
00326  0500 00 0 00404  10001  IRG20   CLA     =20
00327  0020 00 0 00341  10001          IRA     ETRG
00330  0500 00 0 00405  10001  IRG21   CLA     =21
00331  0020 00 0 00341  10001          IRA     ETRG
00332  0500 00 0 00406  10001  IRG22   CLA     =22
00333  0020 00 0 00341  10001          IRA     ETRG
00334  0500 00 0 00407  10001  IRG23   CLA     =23
00335  0020 00 0 00341  10001          IRA     ETRG
00336  0500 00 0 00410  10001  IRG24   CLA     =24
00337  0020 00 0 00341  10001          IRA     ETRG
00340  0500 00 0 00411  10001  IRG25   CLA     =25
00341  0601 00 0 00354  10001  ETRG    STO*    NTRG
00342  0500 00 0 00364  10001          CLA     =4                  SMK01620
00343  0020 00 0 00176  10001          IRA     EXIT                SMK01630
                                                                   SMK01640
```

ASSEMBLED TEXT.

```
BINARY CARD (NOT PUNCHED)
          00344  0500 00 0 00365  10001   EMARK CLA     =5                    SMK01650
          00345  0020 00 0 00176  10001         TRA     EXIT                  SMK01660
          00346  0 00000 0 00000  10000   IX1   PZE                           SMK01670
          00347  0 00000 0 00000  10000   IX2   PZE                           SMK01680
          00350  0 00000 0 00000  10000   IX4   PZE                           SMK01690
          00351  0 00173 0 00171  10101   ADER  PZE     DER1,0,DER2           SMK01700
          00352  0 00000 0 00000  10000   AINV  PZE                           SMK01710
          00353  0 00000 0 00000  10000   NRIN  PZE                           SMK01720
          00354  0 00000 0 00000  10000   NTRG  PZE                           SMK01730
          00355  000000000000     10000         *LOIR
          00356  624442026060     10000
          00357  000000000003     10000         *LORG
          00360  000000000001     10000
          00361  777777000000     10000
          00362  000000000000     10000
          00363  000000000002     10000
          00364  000000000004     10000
          00365  000000000005     10000
          00366  000000000006     10000

BINARY CARD (NOT PUNCHED)
          00367  000000000007     10000
          00370  000000000010     10000
          00371  000000000011     10000
          00372  000000000012     10000
          00373  000000000013     10000
          00374  000000000014     10000
          00375  000000000015     10000
          00376  000000000016     10000
          00377  000000000017     10000
          00400  000000000020     10000
          00401  000000000021     10000
          00402  000000000022     10000
          00403  000000000023     10000
          00404  000000000024     10000
          00405  000000000025     10000
          00406  000000000026     10000
          00407  000000000027     10000
          00410  000000000030     10000
          00411  000000000031     10000

BINARY CARD (NOT PUNCHED)
                       00000  01111         END                             SMK01740
```

CONTROL DICTIONARY

$CDICT SMK2 SMK20002

BINARY CARD (NOT PUNCHED)

000412000000 000004000005		PREFACE	START=0,LENGTH=266,TYPE=7094,CMPLX=5
624442026060 000412000000	SMK2	DECK	
624421514260 000000000000	SMARK	REAL	SECT. 2,LOC=0,LENGTH=0
624421514260 000000000000	SMARK	REAL	SECT. 3,LOC=0,LENGTH=0
635121010460 000000000203	TRA14	REAL	SECT. 4,LOC=203,LENGTH=0
635121020460 000000000210	TRA24	REAL	SECT. 5,LOC=210,LENGTH=0
464560606060 000000000215	ON	REAL	SECT. 6,LOC=215,LENGTH=0
464560606060 000000000215	ON	REAL	SECT. 7,LOC=215,LENGTH=0
462626606060 000000000236	OFF	REAL	SECT. 8,LOC=236,LENGTH=0
462626606060 000000000236	OFF	REAL	SECT. 9,LOC=236,LENGTH=0
627062434623 200000000000	SYSLOC	VIRTUAL	SECT. 10

BINARY CARD (NOT PUNCHED)

256422215160 200000000000	EUBAR	VIRTUAL	SECT. 11
254322215160 200000000000	ELBAR	VIRTUAL	SECT. 12
304421676360 200000000000	HMAXT	VIRTUAL	SECT. 13
304431456360 200000000000	HMINT	VIRTUAL	SECT. 14
702343466660 200000000000	YCLOW	VIRTUAL	SECT. 15
512725515160 200000000000	RGERR	VIRTUAL	SECT. 16
442151426060 200000000000	MARK	VIRTUAL	SECT. 17

$DKEND SMK2 SMK20003

NO MESSAGES FOR THIS ASSEMBLY

SYMBOL REFERENCE DATA

REFERENCES TO DEFINED SYMBOLS.

CLASS	SYMBOL	VALUE	REFERENCES
	ADER	00351	15
	AINV	00352	25,60
	CMARK	00100	10,21,70
	DER1	00171	102,351
	DER2	00173	102,351
	EMARK	00344	103
	ENTRG	00072	56,77
	EOS	00167	101
	ETRG	00341	261,263,265,267,271,273,275,277,301,303,305,307,311,313,315,317,321,323,325,327,331,333,335, 337
	EXIT	00176	170,172,174,343,345
	GTRG	00175	
	IX1	00346	177,205,212
	IX2	00347	200,206,213
	IX4	00350	176,204,211
	..0001	00003	7,10,11
	..0002	00004	
	..0003	00005	0
	..0004	00220	224,225,226
	..0005	00221	
	..0006	00222	215
	..0007	00241	245,246,247
	..0008	00242	
	..0009	00243	256
	NOFTRG	00031	70,77
	NRTN	00353	35,201
	NTRG	00354	37,341
	OFF	00236	236,236,257
	ON	00215	215,215,235
LCTR	BLCTR		
QUAL	UNOS		
LCTR	//		
	SMARK	00000	0,0,202
	STON	00033	25
	STRG	00054	71
	TRA14	00203	210
	TRA24	00210	215
	TRG10	00302	126
	TRG11	00304	130
	TRG12	00306	132
	TRG13	00310	134
	TRG14	00312	136
	TRG15	00314	140
	TRG16	00316	142
	TRG17	00320	144
	TRG18	00322	146
	TRG19	00324	150
	TRG1	00260	104
	TRG20	00326	152
	TRG21	00330	154
	TRG22	00332	156

SYMBOL REFERENCE DATA

TRG23	00334	160
TRG24	00336	162
TRG25	00340	164
TRG2	00262	106
TRG3	00264	110
TRG4	00266	112
TRG5	00270	114
TRG6	00272	116
TRG7	00274	120
TRG8	00276	122
TRG9	00300	124
TRG	00104	64,66,72,75,232,234,253,256

REFERENCES TO VIRTUAL SYMBOLS.

ELBAR	12	43
EUBAR	11	41
HMAXT	13	45
HMINI	14	47
MARK	17	100
RGERR	16	52
SYSLOC	10	5,222,243
YCLOW	15	51

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*IBLDR MARS
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02/17/69 MARS0000

MARS 02/17/69 PAGE
ASSEMBLED TEXT.

```
                    *TEXT  MARS                                                                    MARS0001
                                    *       MARK    RUNGE-KUTTA,ADAMS-MOULTON INTEGRATOR PACKAGE                    MARK0001
                                    *       CALLING SEQUENCE                                                        MARK0002
                                    *       CALL    MARK                                                            MARK0003
                                    *       PZE     HBANK,P,EOS                                                     MARK0004
                                    *       PZE     DER1,PHI,DER2                                                   MARK0005
                                    *       ERROR RETURN                                                            MARK0006
                                    *       PZE,MZE BJ,,YJ                                                          MARK0007
                                    *       PZE     ZJ                                                              MARK0008
                                    *       PZE     0                                                               MARK0009
                                    *       MARK,HC,NI                                                              MARK0014
                          00000             ENTRY   MARK                                                            MARK0015
                          00165             ENTRY   HC                                                              MARK0016
                          00166             ENTRY   NI                                                              MARK0017
                          00173     TGLO    ENTRY   TGO                                                             MARK0019
                          00223             ENTRY   Y                                                               MARK0020
                          00224             ENTRY   YDOT
                          00225     Y121    ENTRY   Y(2)                                                            MARK0022
                          00226             ENTRY   Y0
                          00227     Y0121   ENTRY   Y0(2)                                                          MARK0024
                          00326             ENTRY   EUBAR                                                           MARK0025
                          00327             ENTRY   ELBAR                                                           MARK0026
                          00330             ENTRY   HMAXT                                                           MARK0027
                          00331             ENTRY   HMINT                                                           MARK0028
                          00332             ENTRY   YCLOW                                                           MARK0029
                          01671             ENTRY   RGERR
                          00062     OMAR    SET     50

BINARY CARD (NOT PUNCHED)
     00000  0634 00 4 00231  10001    MARK SXA     I4,4                                                            MARK0030
     00001  0534 00 4 00231  10001   RSTRT LXA     I4,4                                                            MARK0031
     00002  0634 00 4 00216  10001         SXA     AEOS,4                                                          MARK0032
     00003  0534 00 1 00231  10001         LXA     I4,1                                                            MARK0033
     00004  0500 00 1 00004  10000         CLA     4,1                                                             MARK0034
     00005  0100 00 0 00406  10011         TZE     *+6                                                             MARK0035
     00006  4734 00 2 00000  10000         PDX     0,2                                                             MARK0036
     00007  7 00000 2 00403  10011         TXL     *+3,2,0                                                         MARK0037
     00010  0500 00 0 00400  10011         CLA     *                                                               MARK0038
     00011  0625 00 1 00004  10000         STT     4,1                                                             MARK0039
     00012  1 77776 1 00406  10011         TXI     *-6,1,-2                                                        MARK0040
     00013  0500 00 4 00001  10000         CLA     1,4                                                             MARK0041
     00014  0625 00 0 00245  10001         STT     P                                                               MARK0042
     00015  0734 00 1 00400  10011         PAX     *,1                                                             MARK0043
     00016  1 77775 1 00401  10011         TXI     *+1,1,-3                                                        MARK0044
     00017  0634 00 1 00242  10001         SXA     L(M),1                                                          MARK0045
     00020  1 00005 1 00401  10011         TXI     *+1,1,5                                                         MARK0046
     00021  0634 00 1 00243  10001         SXA     L(T1),1                                                         MARK0047
     00022  1 00001 1 00401  10011         TXI     *+1,1,1                                                         MARK0048

BINARY CARD (NOT PUNCHED)
     00023  0634 00 1 00244  10001         SXA     L(T2),1                                                         MARK0049
     00024  0774 00 1 00000  10000         AXT     0,1             STORE USER H BANK                               MARK0050
     00025  0500 60 0 00242  10001   CLA*  L(M)                    IN MARK COMMUNC AREA                            MARK0051
     00026  0601 00 1 00232  10001         STO     M,1                                                             MARK0052
     00027  1 77777 1 00401  10011         TXI     *+1,1,-1                                                        MARK0053
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00030  3 77774 1 40403  10011    IXH   *-3,1,-4                          MARK0054
00031  0500 60 0 00242  10001    CLA*  L(M)                              MARK0055
00032  0621 00 0 00256  10001    STA   N                                 MARK0056
00033  0771 00 0 00022  10000    ARS   18                                MARK0057
00034  0621 00 0 00257  10001    STA   (N)                               MARK0058
00035  0500 60 0 00243  10001    CLA*  L(T1)                            MARK0059
00036  0601 00 0 00240  10001    STO   T1                                MARK0060
00037  0500 60 0 00244  10001    CLA*  L(T2)                            MARK0061
00040  0601 00 0 00241  10001    STO   T2                                MARK0062
00041  0534 00 4 00251  10001    LXA   I4,4                              MARK0063
00042  0500 00 4 00002  10000    CLA   2,4                               MARK0064
00043  0621 00 0 00250  10001    STA   DER1                              MARK0065
00044  0765 00 0 00022  10000    LRS   18                                MARK0066
00045  0621 00 0 00247  10001    STA   DER2                              MARK0067

BINARY CARD (NOT PUNCHED)
00046  4754 00 0 00000  10000    PXD   0,0
00047  0131 00 0 00000  10000    XCA                 PHI TEST            MARK0069
00050  0771 00 0 00040  10000    ARS   32                                MARK0070
00051  0601 00 0 00246  10001    STO   PHI                               MARK0071
00052  0734 00 1 00400  10011    PAX   *,1                               MARK0072
00053  0600 00 0 00251  10001    STZ   E
00054  0020 00 1 00405  10011    TRA   *+5,1                             MARK0073
00055  0771 00 0 00002  10000    ARS   2             PHI=4 - AM WITH AEC  MARK0074
00056  0020 00 0 00403  10011    TRA   *+3                               MARK0075
00057  0760 00 0 00006  10000    COM                 PHI=2 - NO AM       MARK0076
00060  0020 00 0 00406  10011    TRA   *+6                               MARK0077
00061  0601 00 0 00251  10001    STO   E             PHI=0 - AM NO AEC    MARK0078
00062  0500 00 0 00254  10001    CLA   LSTRT                             MARK0079
00063  0621 00 0 00214  10001    STA   TRIG0                             MARK0080
00064  0500 60 0 00243  10001    CLA*  L(T1)                            MARK0081
00065  0560 60 0 00244  10001    LDQ*  L(T2)                            MARK0082
00066  0601 00 0 00221  10001    STO   TRG2                              MARK0083
00067  4600 00 0 00222  10001    STQ   TRG2+1                            MARK0084
00070  0500 00 0 00235  10001    CLA   H                                 MARK0085

BINARY CARD (NOT PUNCHED)
00071  0601 00 0 01400  10011    STO   HC                                MARK0086
00072  0600 00 0 00167  10001    STZ   J             INITIALIZE J COUNT  MARK0087
00073  0074 00 4 00334  10001    ISX   ADDR,4                           MARK0088
00074  0534 00 1 00251  10001    LXA   E,1                               MARK0089
00075  1 00003 1 00401  10011    TXI   *+1,1,3                           MARK0090
00076  0754 00 1 00000  10000    PXA   0,1           FORM BSS LENGTH     MARK0091
00077  0400 00 0 00232  10001    ADD   M                                 MARK0092
00100  0131 00 0 00000  10000    XCA                                     MARK0093
00101  0200 00 0 00236  10001    MPY   N                                 MARK0094
00102  4600 00 0 00202  10001    STQ   TEMP                              MARK0095
00103  0131 00 0 00000  10000    XCA                                     MARK0096
00104  0400 00 0 00202  10001    ADD   TEMP                              MARK0097
00105  0601 00 0 00202  10001    STO   TEMP                              MARK0098
00106  0560 00 0 00236  10001    LDQ   N                                 MARK0099
00107  0200 00 0 00251  10001    MPY   E                                 MARK0100
00110  0131 00 0 00000  10000    XCA                                     MARK0101
00111  0400 00 0 00202  10001    ADD   TEMP                              MARK0102
00112  4520 00 0 00251  10001    NZT   E                                 MARK0103
00113  0020 00 0 00403  10011    TRA   *+3                               MARK0104
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ASSEMBLED TEXT.

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BINARY CARD (NOT PUNCHED)
00114  0400 00 0 00236  10001        ADD    N                                        MARK0105
00115  0400 00 0 00236  10001        ADD    N                                        MARK0106
00116  0734 00 2 00000  10000        PAX    0,2                                      MARK0107
00117  0535 00 1 03400  10011        LAC    YDOT,1          CLEAR USER BSS AREA      MARK0108
00120  0600 00 1 00000  10000        STZ    0,1                                      MARK0109
00121  1 77777 1 00401  10011        TXI    *+1,1,-1                                 MARK0110
00122  2 00001 2 40402  10011        TIX    *-2,2,1                                  MARK0111
00123  0774 00 1 77777  10000        AXT    -1,1            INITIALIZE NH AND ND     MARK0112
00124  0600 00 0 00233  10001        STZ    NH              IN MARK AND USER BANK    MARK0113
00125  0600 00 0 00234  10001        STZ    ND                                       MARK0114
00126  0600 00 0 00252  10001        STZ    HD                                       MARK0115
00127  0500 60 0 00242  10001        CLA*   L(M)                                     MARK0116
00130  0767 00 0 00022  10000        ALS    18                                       MARK0117
00131  0622 60 0 00242  10001        STD*   L(M)                                     MARK0118
00132  1 77777 1 00401  10011        TXI    *+1,1,-1                                 MARK0119
00133  0500 60 0 00242  10001        CLA*   L(M)                                     MARK0120
00134  0767 00 0 00022  10000        ALS    18                                       MARK0121
00135  0622 60 0 00242  10001        STD*   L(M)                                     MARK0122
00136  4520 00 0 00251  10001        NZT    E                                        MARK0123

BINARY CARD (NOT PUNCHED)
00137  0020 00 0 00405  10011        TRA    *+5                                      MARK0124
00140  0500 00 0 00333  10001        CLA    RGFRK                                    MARK0125
00141  0601 00 0 00751  10001        STO    GT2                                      MARK0126
00142  0600 00 0 01676  10001        STZ    A               STET FLAG WORD =0 FOR 2.0X (AEC)  MARK0127
00143  0020 00 0 00403  10011        TRA    *+3                                      MARK0128
00144  0500 00 0 01252  10001        CLA    ADAMS+2                                  MARK0129
00145  0601 00 0 00751  10001        STO    GT2                                      MARK0130
00146  0522 00 0 00250  10001        XEC    DER1                                     MARK0131
00147  0500 00 0 00240  10001        CLA    T1                                       MARK0132
00150  0760 00 0 00003  10000        SSP                                             MARK0133
00151  0560 00 0 00235  10001        LDQ    H                                        MARK0134
00152  0040 00 0 00402  10011        TLQ    *+2                                      MARK0135
00153  0131 00 0 00000  10000        XCA                    MAX(H,T) IN AC            MARK0136
00154  0402 00 0 00706  10001        SUB    HR09            DIVIDE BY 2**26          MARK0137
00155  0520 00 0 00245  10001        ZET    P                                        MARK0138
00156  0402 00 0 00706  10001        SUB    HR09            DIVIDE AGAIN IF D.P. TIME  MARK0139
00157  0601 00 0 00175  10001        STO    DELU            DELTA SUB U              MARK0140
00160  0074 00 4 00414  10001        ISX    ABTB,4              INITIALIZE INTERRUPT S.R.  MARK0141
00161  0020 00 0 00402  10011        TRA    *+2                                      MARK0142

BINARY CARD (NOT PUNCHED)
00162  0020 00 0 00605  10001        TRA    RKC                                      MARK0143
00163  0534 00 4 00231  10001        LXA    I4,4                                     MARK0144
00164  0020 00 4 00003  10000        TRA    3,4             ERROR RETURN             MARK0145
00165  0 00000 0 00000  10000  HC    PZE                                             MARK0146
00166  0 00000 0 00000  10000  NI    PZE    0                                        MARK0147
00167  0 00000 0 00000  10000  J     PZE                                             MARK0148
00170  0 00000 0 00000  10000  TMIN  PZE                                             MARK0149
00171  0 00000 0 00000  10000  TMIN2 PZE                                             MARK0150
00172  0074 00 4 00000  10000  BMIN  ISX    **,4                                     MARK0151
00173  0 00000 0 00000  10000  TG0   PZE                                             MARK0152
00174  0 00000 0 00000  10000  TG02  PZE                                             MARK0153
00175  0 00000 0 00000  10000  DELU  PZE                                             MARK0154
00176  0 00000 0 00000  10000  TL    PZE                                             MARK0155
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00177  0 00000 0 00000  10000    IL2 PZE                                  MARK0156
00200  0 00000 0 00000  10000     IR PZE                                  MARK0157
00201  0 00000 0 00000  10000    IR2 PZE                                  MARK0158
00202  200000000012     00001   TEMP BSS    10                           MARK0159
00214  0 00000 0 00000  10000  TRIGO PZE                                  MARK0160
00215  0 00000 0 00221  10001        PZE    TRG2                         MARK0161

BINARY CARD (NOT PUNCHED)
00216  0761 00 0 00000  10000   AEOS NOP                                  MARK0162
00217  0 00000 4 01777  10001   ASET PZE    SET,4                        MARK0163
00220  0 00000 4 01731  10001  AFLAG PZE    FLAG,4                       MARK0164
00221  200000000002     00001   TRG2 BSS    2                            MARK0165
00223  0 00000 1 00000  10000      Y PZE    **,1                         MARK0166
00224  0 00000 1 00000  10000   YDOT PZE    **,1                         MARK0167
00225  0 00000 1 00000  10000   Y(2) PZE    **,1                         MARK0168
00226  0 00000 1 00000  10000     YU PZE    **,1                         MARK0169
00227  0 00000 1 00000  10000  Y0(2) PZE    **,1                         MARK0170
00230  0 00000 0 00000  10000    MP1 PZE                                  MARK0171
00231  0 00000 0 00000  10000     I4 PZE                                  MARK0172
00232  0 00000 0 00000  10000      M PZE                                  MARK0173
00233  0 00000 0 00000  10000     NH PZE                                  MARK0174
00234  0 00000 0 00000  10000     ND PZE                                  MARK0175
00235  0 00000 0 00000  10000      H PZE                                  MARK0176
00236  0 00000 0 00000  10000      N PZE                                  MARK0177
00237  0 00000 0 00000  10000    (N) PZE                                  MARK0178
00240  0 00000 0 00000  10000     T1 PZE                                  MARK0179
00241  0 00000 0 00000  10000     T2 PZE                                  MARK0180

BINARY CARD (NOT PUNCHED)
00242  0 00000 1 00000  10000   L(M) PZE    **,1                         MARK0181
00243  0 00000 0 00000  10000  L(I1) PZE                                  MARK0182
00244  0 00000 0 00000  10000  L(I2) PZE                                  MARK0183
00245  0 00000 0 00000  10000      P PZE                                  MARK0184
00246  0 00000 0 00000  10000    PHI PZE                                  MARK0185
00247  0074 00 4 00000  10000   DER2 TSX    **,4                         MARK0186
00250  0074 00 4 00000  10000   DER1 TSX    **,4                         MARK0187
00251  0 00000 0 00000  10000      E PZE                                  MARK0188
00252  0 00000 0 00000  10000     HD PZE                                  MARK0189
00253  0 00000 0 00000  10000    HIC PZE                                  MARK0190
00254  0 00000 0 02747  10001  LSTRT PZE    START                        MARK0191
00255  000000000000     10000   DELO DEC    0                            MARK0192
00256  000000000000     10000  GSIGM DEC    0                            MARK0193
00257  0 00000 0 00000  10000     ERC PZE                                  MARK0194
00260  0 00000 1 00000  10000         PZE    **,1                         MARK0195
00261  0 00000 1 00000  10000         PZE    **,1                         MARK0196
00262  0 00000 1 00000  10000         PZE    **,1                         MARK0197
00263  0 00000 1 00000  10000         PZE    **,1                         MARK0198
00264  0 00000 1 00000  10000         PZE    **,1                         MARK0199

BINARY CARD (NOT PUNCHED)
00265  0 00000 1 00000  10000         PZE    **,1                         MARK0200
00266  0 00000 1 00000  10000         PZE    **,1                         MARK0201
00267  0 00000 1 00000  10000         PZE    **,1                         MARK0202
00270  0 00000 1 00000  10000         PZE    **,1                         MARK0203
00271  0 00000 1 00000  10000         PZE    **,1                         MARK0204
00272  0 00000 1 00000  10000         PZE    **,1                         MARK0205
```

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00273  0 00000 1 00000  10000  DELX  PZE   **,1                                  MARK0206
00274  0 00000 1 00000  10000        PZE   **,1                                  MARK0207
00275  0 00000 1 00000  10000        PZE   **,1                                  MARK0208
00276  0 00000 1 00000  10000        PZE   **,1                                  MARK0209
00277  0 00000 1 00000  10000        PZE   **,1                                  MARK0210
00300  0 00000 1 00000  10000        PZE   **,1                                  MARK0211
00301  0 00000 1 00000  10000        PZE   **,1                                  MARK0212
00302  0 00000 1 00000  10000        PZE   **,1                                  MARK0213
00303  0 00000 1 00000  10000        PZE   **,1                                  MARK0214
00304  0 00000 1 00000  10000        PZE   **,1                                  MARK0215
00305  0 00000 1 00000  10000        PZE   **,1                                  MARK0216
00306  0 00000 1 00000  10000        PZE   **,1                                  MARK0217
00307  0 00000 1 00000  10000  DELY  PZE   **,1                                  MARK0218

BINARY CARD (NOT PUNCHED)
00310  0 00000 1 00000  10000        PZE   **,1                                  MARK0219
00311  0 00000 1 00000  10000        PZE   **,1                                  MARK0220
00312  0 00000 1 00000  10000        PZE   **,1                                  MARK0221
00313  0 00000 1 00000  10000        PZE   **,1                                  MARK0222
00314  0 00000 1 00000  10000        PZE   **,1                                  MARK0223
00315  0 00000 1 00000  10000        PZE   **,1                                  MARK0224
00316  0 00000 1 00000  10000        PZE   **,1                                  MARK0225
00317  0 00000 1 00000  10000        PZE   **,1                                  MARK0226
00320  0 00000 1 00000  10000        PZE   **,1                                  MARK0227
00321  0 00000 1 00000  10000        PZE   **,1                                  MARK0228
00322  0 00000 1 00000  10000        PZE   **,1                                  MARK0229
00323  0 00000 1 00000  10000  DELZ  PZE   **,1                                  MARK0230
00324  0 00000 1 00000  10000    YN  PZE   **,1                                  MARK0231
00325  0 00000 1 00000  10000   YN2  PZE   **,1                                  MARK0232
00326  0 00000 0 00000  10000  EUBAR PZE                                         MARK0233
00327  0 00000 0 00000  10000  ELBAR PZE                                         MARK0234
00330  0 00000 0 00000  10000  HMAXT PZE                                         MARK0235
00331  0 00000 0 00000  10000  HMINT PZE                                         MARK0236
00332  0 00000 0 00000  10000  YCLOW PZE                                         MARK0237

BINARY CARD (NOT PUNCHED)
00333  0020 00 0 01000  10001  RGFRK TRA   RGINT                                 MARK0238
00334  0534 00 1 00237  10001   AUDR LXA   (N),1                                MARK0239
00335  4634 00 1 00415  10011        SXD   *+13,1                               MARK0240
00336  0534 00 1 00236  10001        LXA   N,1                                   MARK0241
00337  4634 00 1 00411  10001        SXD   RGAD,1                                MARK0242
00340  4634 00 1 00415  10011        SXD   *+13,1                               MARK0243
00341  4634 00 1 00421  10011        SXD   *+17,1                               MARK0244
00342  0534 00 1 00232  10001        LXA   M,1                                   MARK0245
00343  1 00001 1 00401  10011        TXI   *+1,1,1                              MARK0246
00344  0634 00 1 00230  10001        SXA   MP1,1                                 MARK0247
00345  1 00001 1 00401  10011        TXI   *+1,1,1                              MARK0248
00346  0634 00 1 00411  10011        SXA   *+9,1                                 MARK0249
00347  0534 00 1 00242  10001        LXA   L(M),1                                MARK0250
00350  1 00007 1 00401  10011        TXI   *+1,1,7                              MARK0251
00351  0774 00 2 00005  10000        AXT   5,2                                   MARK0252
00352  1 00400 1 00401  11111        TXI   *+1,1,*                              MARK0253
00353  0754 00 1 00400  10011        PXA   *,1                                   MARK0254
00354  0621 00 2 05001  10011        STA   Y0(2)+1,2                            MARK0255
00355  1 00400 1 00401  11111        TXI   *+1,1,*                              MARK0256
```

UPPER LIMIT OF E(N+1)
LOINER LIMIT OF E(N+1)
MAXIMUM DELTA T
MINIMUM DELTA T
LOWER BOUND OF Y(N+1)C

SET TABLE ADDRESSES

N IN DECRE

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BINARY CARD (NOT PUNCHED)
00356  2 00001 2 40403  10011        TIX   *-3,2,1                                  MARKn257
00357  0774 00 2 00400  10011        AXT   *,2          M+2 IN ADD                  MARKn258
00360  0754 00 1 00400  10011        PXA   *,1                                      MARKn259
00361  0621 00 2 00274  10001        STA   DELX+1,2                                 MARKn260
00362  1 00400 1 00401  11111        TXI   *+1,1,*      N IN DECRE                  MARKn261
00363  2 00001 2 40403  10011        TIX   *-3,2,1                                  MARKn262
00364  0534 00 2 00236  10001        LXA   N,2                                      MARKn263
00365  4634 00 2 00405  10011        SXD   *+5,2                                    MARKn264
00366  0534 00 2 00230  10001        LXA   MP1,2                                    MARKn265
00367  1 00001 2 00401  10011        TXI   *+1,2,1                                  MARKn266
00370  0754 00 1 00400  10011        PXA   *,1                                      MARKn267
00371  0621 00 2 00310  10001        STA   DELY+1,2                                 MARKn268
00372  1 00400 1 00401  11111        TXI   *+1,1,*      N IN DECRE                  MARKn269
00373  2 00001 2 40403  10011        TIX   *-3,2,1                                  MARKn270
00374  4520 00 0 00251  10001        NZT   E                                        MARKn271
00375  0020 00 0 00413  10001        TRA   RGAD+2                                   MARKn272
00376  0534 00 2 00236  10001        LXA   N,2                                      MARKn273
00377  4634 00 2 00405  10011        SXD   *+5,2                                    MARKn274
00400  0534 00 2 00230  10001        LXA   MP1,2                                    MARKn275

BINARY CARD (NOT PUNCHED)
00401  1 00001 2 00401  10011        TXI   *+1,2,1                                  MARKn276
00402  0754 00 1 00400  10011        PXA   *,1                                      MARKn277
00403  0621 00 2 00324  10001        STA   DELZ+1,2                                 MARKn278
00404  1 00000 1 00401  10011        TXI   *+1,1,**                                 MARKn279
00405  2 00001 2 40403  10011        TIX   *-3,2,1                                  MARKn280
00406  0774 00 2 00002  10000        AXT   2,2                                      MARKn281
00407  0754 00 1 00400  10011        PXA   *,1                                      MARKn282
00410  0621 00 2 00000  10011        STA   YN2+1,2                                  MARKn283
       0 00001 7 00325  10001
00411  1 00400 1 00401  11111  RGAD  TXI   *+1,1,*      N IN DECRE                  MARKn284
00412  2 00001 2 40403  10011        TIX   *-3,2,1                                  MARKn285
00413  0020 00 4 00001  10000        TRA   1,4                                      MARKn286
00414  0634 00 1 00573  10001  ABTB  SXA   HA01,1                                   MARKn287
00415  0634 00 2 00572  10001        SXA   HA02,2                                   MARKn288
00416  0634 00 4 00571  10001        SXA   HA03,4                                   MARKn289
                                     ASET AND AFLAG SHOULD BE ASSEMBLED AS         MARKn290
                                     ASET PZE SET,4   AND AFLAG PZE FLAG,4         MARKn291
00417  0500 00 0 00602  10001        CLA   HA12                                     MARKn292
00420  0622 00 0 00217  10001        STO   ASET        ASET NOW CONTAINS NOP        MARKn293
00421  0622 00 0 00220  10001        STO   AFLAG       AFLAG NOW CONTAINS NOP       MARKn294
00422  0500 00 0 00214  10001        CLA   TRIG0                                    MARKn295

BINARY CARD (NOT PUNCHED)
00423  0621 00 0 00172  10001        STA   BMIN                                     MARKn296
00424  0500 00 0 00215  10001        CLA   TRIG0+1                                  MARKn297
00425  0402 00 0 00440  10001        SUB   HA11                                     MARKn298
00426  0621 00 0 00401  10011        STA   *+1                                      MARKn299
00427  0500 00 0 00000  10000        CLA   **                                       MARKn300
00430  0601 00 0 00171  10001        STO   TMIN2                                    MARKn301
00431  0500 60 0 00215  10001        CLA*  TRIG0+1                                 MARKn302
00432  0601 00 0 00170  10001        STO   TMIN                                     MARKn303
00433  0534 00 1 00231  10001        LXA   I4,1         FIND MARK                   MARKn304
00434  0500 00 1 00004  10000  HA04  CLA   4,1                                      MARKn305
00435  0100 00 0 00505  10001        TZE   HA10         END OF TRIGGERS             MARKn306
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00436  0120 00 0 00402  10011          TPL     *+2                                          MARK0307
00437  1 77776 1 00434  10001          TXI     HA04,1,-2       SKIP NEGATIVE TRIGGERS       MARK0308
00440  4734 00 2 00001  10000  HA11    PDX     1,2                SET DEP. VAR. FLAG        MARK0309
00441  7 00000 2 00405  10011          TXL     **+5,2,0            IF INDEPENDENT VARIABLE, JUMP  MARK0310
00442  0500 00 0 00603  10001          CLA     HA13                                         MARK0311
00443  0622 00 0 00217  10001          STD     ASET            ASET NOW CONTAINS TSX        MARK0312
00444  0622 00 0 00220  10001          STD     AFLAG           AFLAG NOW CONTAINS TSX       MARK0313
00445  1 77776 1 00434  10001          TXI     HA04,1,-2                                    MARK0314

BINARY CARD (NOT PUNCHED)
00446  0500 00 1 00005  10000          CLA     5,1                                          MARK0315
00447  0621 00 0 00452  10001          STA     HA05                                         MARK0316
00450  0402 00 0 00440  10001          SUB     HA11                                         MARK0317
00451  0621 00 0 00470  10001          STA     HA06                                         MARK0318
00452  0500 00 0 00000  10000  HA05    CLA     **              T1(I)                        MARK0319
00453  4520 00 0 00245  10001          NZT     P                                            MARK0320
00454  0020 00 0 00404  10011          TRA     **+4                                         MARK0321
00455  0300 60 0 00470  10001          FAD*    HA06            T2(I)                        MARK0322
00456  4600 60 0 00470  10001          STQ*    HA06                                         MARK0323
00457  0601 60 0 00452  10001          STO*    HA05            T1(I)                        MARK0324
00460  0340 00 0 00170  10001          CAS     TMIN                                         MARK0325
00461  1 77776 1 00434  10001          TXI     HA04,1,-2       T1(I)-TMIN=+,CONTINUE SEARCH MARK0326
00462  0020 00 0 00473  10001          TRA     HA07            T1(I)-TMIN=0,CHECK TMIN2 IF P=1  MARK0327
00463  0601 00 0 00170  10001          STO     TMIN            T1(I)-TMIN=-,REPLACE TMIN AND TMIN2  MARK0328
00464  0500 00 1 00004  10000          CLA     4,1                                          MARK0329
00465  0621 00 0 00172  10001          STA     BMIN                                         MARK0330
00466  4520 00 0 00245  10001          NZT     P                                            MARK0331
00467  1 77776 1 00434  10001          TXI     HA04,1,-2       P=0, CONTINUE SEARCH         MARK0332
00470  0500 00 0 00000  10000  HA06    CLA     **              T2 (I)                       MARK0333

BINARY CARD (NOT PUNCHED)
00471  0601 00 0 00171  10001          STO     TMIN2                                        MARK0334
00472  1 77776 1 00434  10001          TXI     HA04,1,-2       NEW TMIN TMIN2, CONTINUE SEARCH  MARK0335
00473  4520 00 0 00245  10001  HA07    NZT     P                                            MARK0336
00474  1 77776 1 00434  10001          TXI     HA04,1,-2       P=0,CONTINUE SEARCH          MARK0337
00475  0500 60 0 00470  10001          CLA*    HA06            T2(I)                        MARK0338
00476  0340 00 0 00171  10001          CAS     TMIN2                                        MARK0339
00477  0761 00 0 00000  10000          NOP                                                  MARK0340
00500  1 77776 1 00434  10001          TXI     HA04,1,-2       T2(I)-TMIN2=+,CONTINUE SEARCH  MARK0341
00501  0601 00 0 00171  10001          STO     TMIN2           T2(I)-TMIN2=-, REPLACE TMIN2 MARK0342
00502  0500 00 1 00004  10000          CLA     4,1                                          MARK0343
00503  0621 00 0 00172  10001          STA     BMIN                                         MARK0344
00504  1 77776 1 00434  10001          TXI     HA04,1,-2       CONTINUE SEARCH              MARK0345
00505  0534 00 1 00231  10001  HA10    LXA     14,1            FIND MARK                    MARK0346
00506  0500 00 1 00002  10000          CLA     2,1                                          MARK0347
00507  0621 00 0 00250  10001          STA     DER1                                         MARK0348
00510  0600 00 0 00202  10001          STZ     TEMP                                         MARK0349
00511  0625 00 0 00202  10001          STT     TEMP            PHI IN T(TEMP)               MARK0350
00512  0771 00 0 00022  10000          ARS     18                                           MARK0351
00513  0621 00 0 00247  10001          STA     DER2                                         MARK0352

BINARY CARD (NOT PUNCHED)
00514  0500 00 1 00001  10000          CLA     1,1                                          MARK0353
00515  0622 00 0 00525  10001          STD     HA08                                         MARK0354
00516  0771 00 0 00022  10000          ARS     18                                           MARK0355
00517  0601 00 0 00203  10001          STO TEMP+1                                           MARK0356
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00520  4100 00 0 00404  10011          TNZ     *+4                GO COMPARE EOS WITH A (AEOS)        MARK0357
00521  0500 00 0 00602  10001          CLA     HA12                                                   MARK035A
00522  0622 00 0 00216  10001          STD     AEOS               SET C(AEOS)=NOP                     MARK0359
00523  0020 00 0 00534  10001          TRA     HA09               CONTINUE                            MARK0360
00524  0535 00 2 00216  10001          LAC     AEOS,2                                                 MARK0361
00525  1 00000 2 00401  10011  HA08    TXI     *+1,2,**                                               MARK0362
00526  7 00000 2 00534  10001          TXL     HA09,2,0           EOS=A(AEOS)                         MARK0363
00527  0500 00 0 00603  10001          CLA     HA13                                                   MARK0364
00530  0601 00 0 00216  10001          STO     AEOS               C(AEOS)=TSX **,4                    MARK0365
00531  0500 00 0 00203  10001          CLA TEMP+1                                                     MARK0366
00532  0621 00 0 00216  10001          STA     AEOS               A(AEOS)=NEW EOS                     MARK0367
00533  0522 00 0 00216  10001          XEC     AEOS                                                   MARK0368
00534  0500 00 0 00202  10001  HA09    CLA     TEMP                                                   MARK0369
00535  0771 00 0 00017  10000          ARS     15                                                     MARK0370
00536  0601 00 0 00202  10001          STO     TEMP               PHI IN A(TEMP)                      MARK0371

BINARY CARD (NOT PUNCHED)
00537  0402 00 0 00246  10001          SUB     PHI                                                    MARK0372
00540  0100 00 0 00542  10001          TZE     HA16                PHI UNCHANGED                      MARK0373
00541  0020 00 0 00001  10001          TRA     RSTRT              PHI AND RESTART                     MARK0374
00542  0774 00 1 77774  10000  HA16    AXT     -4,1                                                   MARK0375
00543  0500 60 0 00242  10001          CLA*    L(M)               PICK UP N,,(N)                      MARK0376
00544  0771 00 0 00022  10000          ARS     18                                                     MARK0377
00545  0340 00 0 00237  10001          CAS     (N)                                                    MARK0378
00546  0020 00 0 00001  10001          TRA     RSTRT               (N) BIGGER, RESTART                MARK0379
00547  0020 00 0 00403  10011          TRA     *+3                (N) UNCHANGED, CONTINUE             MARK0380
00550  0601 00 0 00237  10001          STO     (N)                                                    MARK0381
00551  0074 00 4 00334  10001          TSX     ADDR,4             FIX DELX ADDRESSES FOR NEW (N)      MARK0382
00552  0774 00 1 77775  10000          AXT     -3,1                                                   MARK0383
00553  0500 60 0 00242  10001          CLA*    L(M)                                                   MARK0384
00554  0601 00 0 00235  10001          STO     H                                                      MARK0385
00555  0774 00 1 77777  10000          AXT     -1,1               MODIFY NH AND ND BY                 MARK0386
00556  0500 60 0 00242  10001          CLA*    L(M)               AMOUNT OF USER CHANGE               MARK0387
00557  0400 00 0 00233  10001          ADD     NH                                                     MARK0388
00560  0621 00 0 00233  10001          STA     NH                                                     MARK0389
00561  0767 00 0 00022  10000          ALS     18                                                     MARK039N

BINARY CARD (NOT PUNCHED)
00562  0601 60 0 00242  10001          STO*    L(M)                                                   MARK0391
00563  1 77777 1 00401  10011          TXI     *+1,1,-1                                               MARK0392
00564  0500 60 0 00242  10001          CLA*    L(M)                                                   MARK0393
00565  0400 00 0 00234  10001          ADD     ND                                                     MARK0394
00566  0621 00 0 00234  10001          STA     ND                                                     MARK0395
00567  0767 00 0 00022  10000          ALS     18                                                     MARK0396
00570  0601 60 0 00242  10001          STO*    L(M)                                                   MARK0397
00571  0774 00 4 00000  10000  HA03    AXT     **,4                                                   MARK039A
00572  0774 00 2 00000  10000  HA02    AXT     **,2                                                   MARK0399
00573  0774 00 1 00000  10000  HA01    AXT     **,1                                                   MARK0400
00574  0500 00 0 00170  10001          CLA     TMIN                                                   MARK0401
00575  0302 00 0 00240  10001          FSB     T1                 IF TMIN-T1=- AND P=0                MARK0402
00576  4520 00 0 00245  10001          NZT     P                  THEN CHECK TO SEE IF TMIN           MARK0403
00577  0300 00 0 00175  10001          FAD     DELU               IS WITHIN DELU OF T1                MARK0404
00600  4120 00 4 00001  10000          TMI     1,4                                                    MARK0405
00601  0020 00 4 00002  10000          TRA     2,4                                                    MARK0406
00602  0761 00 0 00000  10000  HA12    NOP                                                            MARK0407
00603  0074 00 4 00000  10000  HA13    TSX     **,4                                                   MARK0408
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00604  000000000002     10000    HA14 OCT    2                                  MARK0409

BINARY CARD (NOT PUNCHED)
00605  0500 00 0 00240  10001    RKC  CLA    T1                                 MARK0410
00606  0760 00 0 00003  10000         SSP                                       MARK0411
00607  0560 00 0 00235  10001         LDQ    H                                  MARK0412
00610  0040 00 0 00402  10011         TLQ    **2                                MARK0413
00611  0131 00 0 00000  10000         XCA                 MAX (H,T) IN AC        MARK0414
00612  0402 00 0 00706  10001         SUB    HR09         DIVIDE BY 2**26       MARK0415
00613  0520 00 0 00245  10001         ZET    P                                  MARK0416
00614  0402 00 0 00710  10001         SUB    HR13         DIVIDE AGAIN IF D.P. TIME MARK0417
00615  0601 00 0 00175  10001         STO    DELU         DELTA                 MARK041A
00616  0500 00 0 00170  10001    HR04 CLA    TMIN                               MARK041B
00617  0302 00 0 00240  10001         FSB    T1                                 MARK0420
00620  0601 00 0 00202  10001         STO    TEMP                               MARK0421
00621  0131 00 0 00000  10000         XCA                                       MARK0422
00622  0302 00 0 00241  10001         FSB    T2                                 MARK0423
00623  0300 00 0 00171  10001         FAD    TMIN2                              MARK0424
00624  0300 00 0 00202  10001         FAD    TEMP                               MARK0425
00625  0602 00 0 00711  10001         SLW    HR03                               MARK0426
00626  0300 00 0 00175  10001         FAD    DELU                               MARK0427
00627  0120 00 0 00403  10011         TPL    **3                                MARK0428

BINARY CARD (NOT PUNCHED)
00630  0534 00 4 00231  10001    HR11 LXA    I4,4                               MARK0429
00631  0020 00 4 00003  10000         TRA    3,4          TIME ERROR            MARK0430
00632  0500 00 0 00711  10001         CLA    HR03                               MARK0431
00633  0560 00 0 00175  10001         LDQ    DELU                               MARK0432
00634  0040 00 0 00642  10001         TLQ    HR02         TRANSFER IF T NOT WITHIN MARK0433
00635  0522 00 0 00172  10001         XEC    BMIN         DELTA OF TMIN         MARK0434
00636  0020 00 0 00401  10011         TRA    **1                                MARK0435
00637  0074 00 4 00414  10001         ISX    ARTB,4       GET NEW TMIN          MARK0436
00640  0020 00 0 00630  10001         TRA    HR11                               MARK0437
00641  0020 00 0 00616  10001         TRA    HR04                               MARK0438
00642  0500 00 0 00711  10001    HR02 CLA    HR03         TMIN-T                MARK0439
00643  0560 00 0 00235  10001         LDQ    H                                  MARK0440
00644  4600 00 0 01400  10011         STO    HC                                 MARK0441
00645  0040 00 0 00402  10011         TLQ    **2                                MARK0442
00646  0601 00 0 01400  10011         STO    HC           HC=MIN(H,TMIN-T)      MARK0443
00647  0522 00 0 00217  10001         XEC    ASET                               MARK0444
00650  0074 00 4 01131  10001         ISX    KUTTA,4      INTEGRATE TO T+DT     MARK0445
00651  0500 00 0 00240  10001         CLA    T1                                 MARK0446
00652  0560 00 0 00241  10001         LDQ    T2                                 MARK0447

BINARY CARD (NOT PUNCHED)
00653  0601 00 0 02400  10011         STO    TG0                                MARK0448
00654  4600 00 0 00174  10001         STO    TG02                               MARK0449
00655  0522 00 0 00216  10001         XEC    AEOS                               MARK0450
00656  0522 00 0 00220  10001         XEC    AFLAG                              MARK0451
00657  0020 00 0 00605  10001         TRA    RKC          NORMAL RETURN         MARK0452
00660  0074 00 4 02263  10001    HR12 ISX    SRCH,4       FLAG RETURN           MARK0453
00661  0020 00 0 00606  10001         TRA    HR05         CON                   MARK0454
00662  0601 00 0 01400  10011         STO    HC           RAK                   MARK0455
00663  0074 00 4 01131  10001    HR01 ISX    KUTTA,4                            MARK0456
00664  0522 00 0 00216  10001         XEC    AEOS                               MARK0457
00665  0020 00 0 00600  10001         TRA    HR12                               MARK0458
```

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00666  0534 00 1 00231  10001  HR05 LXA  I4,1                                  MARK0459
00667  0500 00 1 00004  10000  HR07 CLA  4,1                                   MARK0460
00670  0100 00 0 00605  10001       TZE  RKC      END OF TRIGGERS              MARK0461
00671  4320 00 0 00707  10001       ANA  HR10                                  MARK0462
00672  0100 00 0 00705  10001       TZE  HR08                                  MARK0463
00673  0634 00 1 00405  10011       SXA  *+5,1
00674  0500 00 1 00004  10000       CLA  4,1                                   MARK0464
00675  0621 00 0 00401  10011       STA  *+1                                   MARK0465

BINARY CARD (NOT PUNCHED)
00676  0074 00 4 00000  10000       TSX  **,4     EXECUTE BMIN                 MARK0466
00677  0020 00 0 00401  10011       TRA  *+1                                   MARK0467
00700  0774 00 1 00000  10000       AXT  **,1
00701  0500 00 0 40402  10011       CLA  *-2
00702  0625 00 1 00004  10000       STT  4,1      SET TAG OF EXECUTED TRIGGER = 0
00703  0074 00 4 00414  10001       TSX  ABTB,4   UPDATE TMIN                  MARK0468
00704  0020 00 0 00630  10001       TRA  HR11                                  MARK0469
00705  1 77776 1 00667  10001  HR08 TXI  HR07,1,-2                             MARK0470
00706  032000000000     10000  HR09 OCT  32000000000                          MARK0471
00707  000000400000     10000  HR10 OCT  400000                               MARK0472
00710  032000000000     10000  HR11 OCT  32000000000                          MARK0473
00711  000000000000     10000  HR03 OCT  0                                    MARK0474
00712  4520 00 0 00245  10001  AMC  NZT  P      ADAMS-MOULTON CONTROL          MARK0475
00713  0020 00 0 00405  10011       TRA  *+5                                   MARK0476
00714  0074 00 4 02716  10001       TSX  DSUB,4                                MARK0477
00715  0 00170 0 00240  10101       PZE  T1,0,TMIN                             MARK0478
00716  0760 00 0 00003  10000       SSP                                        MARK0479
00717  0020 00 0 00404  10011       TRA  *+4                                   MARK0480
00720  0500 00 0 00240  10001       CLA  T1                                    MARK0481

BINARY CARD (NOT PUNCHED)
00721  0302 00 0 00170  10001       FSB  TMIN                                  MARK0482
00722  0760 00 0 00003  10000       SSP                                        MARK0483
00723  0340 00 0 00175  10001       CAS  DELU                                  MARK0484
00724  0020 00 0 00734  10001       TRA  GT1                                   MARK0485
00725  0761 00 0 00000  10000       NOP                                        MARK0486
00726  0522 00 0 00172  10001       XEC  BMIN                                  MARK0487
00727  0020 00 0 00402  10011       TRA  *+2                                   MARK0488
00730  0020 00 0 00001  10001       TRA  RSTRT    RESTART                      MARK0489
00731  0074 00 4 00414  10001  GTU  TSX  ABTB,4   ENTRY FROM START              MARK0490
00732  0020 00 0 01127  10001       TRA  GT10+1   ERROR RETURN                 MARK0491
00733  0020 00 0 00712  10001       TRA  AMC                                   MARK0492
00734  0522 00 0 00217  10001  GT1  XEC  ASET     DO SET ROUTINE               MARK0493
00735  4520 00 0 00245  10001       NZT  P                                     MARK0494
00736  0020 00 0 00405  10011       TRA  *+5                                   MARK0495
00737  0074 00 4 02716  10001       TSX  DSUB,4                                MARK0496
00740  0 02400 0 00240  11101       PZE  T1,0,TGO                              MARK0497
00741  0760 00 0 00003  10000       SSP                                        MARK0498
00742  0020 00 0 00404  10011       TRA  *+4                                   MARK0499
00743  0500 00 0 00240  10001       CLA  T1                                    MARK0500

BINARY CARD (NOT PUNCHED)
00744  0302 00 0 02400  10011       FSB  TGO                                   MARK0501
00745  0760 00 0 00003  10000       SSP                                        MARK0502
00746  0340 00 0 00175  10001       CAS  DELU                                  MARK0503
00747  0020 00 0 01015  10001       TRA  GT3                                   MARK0504
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ASSEMBLED TEXT.

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00750  0761 00 0 00000  10000          NOP                                  MARK0505
00751  0761 00 0 00000  10000   GT2    NOP            AEC FORK              MARK0506
00752  4520 00 0 00233  10001          NZT    NH                            MARK0507
00753  0020 00 0 00410  10011          TRA    *+8                           MARK0508
00754  0074 00 4 03162  10001          TSX    X,50,4         HALVE INTERVAL MARK0509
00755  0774 00 1 77777  10000          AXT    -1,1                          MARK0510
00756  0534 00 2 00233  10001          LXA    NH,2                          MARK0511
00757  1 77777 2 00401  10011          TXI    *+1,2,-1                      MARK0512
00760  0634 00 2 00233  10001          SXA    NH,2                          MARK0513
00761  4754 00 2 00000  10000          PXD    0,2                           MARK0514
00762  0622 60 0 00242  10001          STD*   L(M)                          MARK0515
00763  4520 00 0 00234  10001          NZT    ND                            MARK0516
00764  0020 00 0 00414  10011          TRA    *+12                          MARK0517
00765  0520 00 0 00232  10001          ZET    HD                            MARK0518
00766  0020 00 0 00412  10011          TRA    *+10                          MARK0519

BINARY CARD (NOT PUNCHED)
00767  0074 00 4 03024  10001          TSX    X2,0,4         DOUBLE INTERVAL MARK0520
00770  0774 00 1 77776  10000          AXT    -2,1                          MARK0521
00771  0534 00 2 00234  10001          LXA    ND,2                          MARK0522
00772  1 77777 2 00401  10011          TXI    *+1,2,-1                      MARK0523
00773  0634 00 2 00234  10001          SXA    ND,2                          MARK0524
00774  4754 00 2 00000  10000          PXD    0,2                           MARK0525
00775  0622 60 0 00242  10001          STD*   L(M)                          MARK0526
00776  0074 00 4 00414  10001          TSX    ARTB,4         FIND NEW TMIN  MARK0527
00777  0020 00 0 01127  10001          TRA    GT10+1         ERROR RETURN   MARK0528
01000  0074 00 4 01250  10001   RGINT  TSX    ADAMS,4        INTEGRATE      MARK0529
01001  0500 00 0 00240  10001          CLA    T1                            MARK0530
01002  0560 00 0 00241  10001          LDQ    T2                            MARK0531
01003  0601 00 0 02400  10011          STO    TGO                           MARK0532
01004  4600 00 0 00174  10001          STQ    TGO2                          MARK0533
01005  0760 00 0 00003  10000          SSP                   FORM DELU      MARK0534
01006  0560 00 0 01400  10011          LDQ    HC                            MARK0535
01007  0040 00 0 00402  10011          TLQ    *+2                           MARK0536
01010  0131 00 0 00000  10000          XCA                   HC IN AC       MARK0537
01011  0520 00 0 00245  10001          ZET    P                             MARK0538

BINARY CARD (NOT PUNCHED)
01012  0402 00 0 01126  10001          SUB    GT10                          MARK0539
01013  0402 00 0 01126  10001          SUB    GT10                          MARK0540
01014  0601 00 0 00175  10001          STO    DELU                          MARK0541
01015  0500 00 0 00175  10001   GT5    CLA    DELU                          MARK0542
01016  0760 00 0 00002  10000          CHS                                  MARK0543
01017  0300 00 0 00174  10001          FAD    TGO2                          MARK0544
01020  0300 00 0 02400  10011          FAD    TGO                           MARK0545
01021  0601 00 0 00202  10001          STO    TEMP                          MARK0546
01022  4600 00 0 00203  10001          STQ    TEMP+1                        MARK0547
01023  0500 00 0 00202  10001          CLA    TEMP                          MARK0548
01024  0340 00 0 00170  10001          CAS    TMIN                          MARK0549
01025  0020 00 0 01046  10001          TRA    GT5                           MARK0550
01026  0020 00 0 00402  10011          TRA    *+2                           MARK0551
01027  0020 00 0 01034  10001          TRA    GT4                           MARK0552
01030  0500 00 0 00203  10001          CLA    TEMP+1                        MARK0553
01031  0340 00 0 00171  10001          CAS    TMIN2                         MARK0554
01032  0761 00 0 00000  10000          NOP                                  MARK0555
01033  0020 00 0 01046  10001          TRA    GT5                           MARK0556
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01034  0500 00 0 02400  10011     GT4 CLA     TGO                                  MARK0557

BINARY CARD (NOT PUNCHED)
01035  0601 00 0 00240  10001         STO     T1                                   MARK0558
01036  0601 60 0 00243  10001         STO*    L(T1)                                MARK0559
01037  0500 00 0 00174  10001         CLA     TGO2                                 MARK0560
01040  0601 00 0 00241  10001         STO     T2                                   MARK0561
01041  0601 60 0 00244  10001         STO*    L(T2)                                MARK0562
01042  0074 00 4 03007  10001         TSX     PUTB,4                               MARK0563
01043  0522 00 0 00216  10001         XEC     AEOS                                 MARK0564
01044  0020 00 0 01055  10001         TRA     GT6                                  MARK0565
01045  0020 00 0 00001  10001         TRA     RSTRT       RESTART                  MARK0566
01046  0500 00 0 00170  10001     GT5 CLA     TMIN                                 MARK0567
01047  0601 00 0 00240  10001         STO     T1                                   MARK0568
01050  0601 60 0 00243  10001         STO*    L(T1)                                MARK0569
01051  0500 00 0 00171  10001         CLA     TMIN2                                MARK0570
01052  0601 00 0 00241  10001         STO     T2                                   MARK0571
01053  0601 60 0 00244  10001         STO*    L(T2)                                MARK0572
01054  0074 00 4 02442  10001         TSX     INTRP,4                              MARK0573
01055  0522 00 0 00220  10001     GT6 XEC     AFLAG       FLAG SUBROUTINE          MARK0574
01056  0020 00 0 00712  10001         TRA     AMC                                  MARK0575
01057  0074 00 4 02263  10001         TSX     SRCH,4      FLAG RETURN              MARK0576

BINARY CARD (NOT PUNCHED)
01060  0020 00 0 01072  10001         TRA     GT8                                  MARK0577
01061  0500 00 0 00241  10001         CLA     T2                                   MARK0578
01062  0300 00 0 00253  10001         FAD     HIC                                  MARK0579
01063  0300 00 0 00240  10001         FAD     T1                                   MARK0580
01064  0601 00 0 00240  10001         STO     T1                                   MARK0581
01065  0601 60 0 00243  10001         STO*    L(T1)                                MARK0582
01066  4600 00 0 00241  10001         STO     T2                                   MARK0583
01067  4600 60 0 00244  10001         STO*    L(T2)                                MARK0584
01070  0074 00 4 02442  10001         TSX     INTRP,4                              MARK0585
01071  0020 00 0 01057  10001         TRA     GT6+2                                MARK0586
01072  0600 00 0 01125  10001     GT8 STZ     STAR                                 MARK0587
01073  0534 00 4 00231  10001         LXA     I4,4                                 MARK0588
01074  0500 00 4 00004  10000         CLA     4,4                                  MARK0589
01075  0100 00 0 01114  10001         TZE     GT9                                  MARK0590
01076  4120 00 0 01101  10001         TMI     GT11                                 MARK0591
01077  0771 00 0 00021  10000         ARS     17                                   MARK0592
01100  0760 00 0 00001  10000         LRI                                          MARK0593
01101  1 77776 4 01074  10001     GT11 TXI    GT8+2,4,-2                           MARK0594
01102  0634 00 4 00406  10011         SXA     *+6,4                                MARK0595

BINARY CARD (NOT PUNCHED)
01103  0500 00 4 00004  10000         CLA     4,4                                  MARK0596
01104  0621 00 0 00401  10011         STA     *+1                                  MARK0597
01105  0074 00 4 00400  10011         TSX     *,4         EXECUTE INTERRUPTION     MARK0598
01106  0020 00 0 00402  10011         TRA     *+2                                  MARK0599
01107  0020 00 0 01122  10001         TRA     GT12                                 MARK0600
01110  0774 00 4 00400  10011     GT13 AXT    *,4                                  MARK0601
01111  0500 00 0 40402  10011         CLA     *-2         CLEAR 5 FROM TAG         MARK0602
01112  0625 00 4 00004  10000         STI     4,4                                  MARK0603
01113  0020 00 0 01101  10001         TRA     GT11                                 MARK0604
01114  0074 00 4 00414  10001     GT9 TSX     ABTB,4                               MARK0605
01115  0020 00 0 01127  10001         TRA     GT10+1      ERROR RETURN             MARK0606
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01116  0522 00 0 00217  10001        XFC   ASET      SET SUBROUTINE          MARK0607
01117  0520 00 0 01145  10001        ZFT   STAR                              MARK0608
01120  0020 00 0 00001  10001        TRA   RSTRT                             MARK0609
01121  0020 00 0 01015  10001        TRA   GT3                               MARK0610
01122  0500 00 0 00400  10011  G112  CLA   *                                 MARK0611
01123  0601 00 0 01145  10001        STO   STAR                              MARK0612
01124  0020 00 0 01110  10001        TRA   GT13                              MARK0613
01125  0 00000 0 00000  10000  STAR  PZE                     FLAG FOR RESTART MARK0614

BINARY CARD (NOT PUNCHED)
01126  032000000000     10000  G110  OCT   32000000000                       MARK0615
01127  0534 00 4 00231  10001        LXA   14,4                              MARK0616
01130  0020 00 4 00003  10000        TRA   3,4         ERROR RETURN          MARK0617
01131  0634 00 1 01201  10001  KUITA SXA   HK08,1                            MARK0618
01132  0634 00 2 01202  10001        SXA   HK09,2                            MARK0619
01133  0634 00 4 01203  10001        SXA   HK10,4                            MARK0620
01134  0500 00 0 01400  10011        CLA   HC                                MARK0621
01135  0240 00 0 01246  10001        FDH   HK12                              MARK0622
01136  4600 00 0 00203  10001        STQ   TEMP+1       DT/2                  MARK0623
01137  0600 00 0 00202  10001        STZ   TEMP                              MARK0624
01140  0534 00 1 00237  10001        LXA   (N),1                            MARK0625
01141  0500 60 0 03000  10011        CLA*  Y                                 MARK0626
01142  0601 60 0 04400  10011        STO*  Y0          SAVE INITIAL VALUES OF Y(I) MARK0627
01143  2 00001 1 40402  10011        TIX   *-2,1,1                           MARK0628
01144  0774 00 4 00004  10000        AXT   4,4                               MARK0629
01145  0534 00 1 00237  10001  HK01  LXA   (N),1                            MARK0630
01146  0754 00 4 00001  10000        PXA   1,4                               MARK0631
01147  4320 00 0 40401  10011        ANA   *-1         GET BIT 35            MARK0632
01150  0734 00 2 00000  10000        PAX   ,2          C(XR2)=1 OR 0         MARK0633

BINARY CARD (NOT PUNCHED)
01151  0560 60 0 03400  10011        LDQ*  YDOT                              MARK0634
01152  0260 00 0 01400  10011        FMP   HC                                MARK0635
01153  0020 60 4 01245  10001        TRA*  HK11,4      SWITCH FOR PASSES 1-4 MARK0636
01154  2 00001 1 40403  10011  HK03  TIX   *-3,1,1     DO (N)                MARK0637
01155  0500 00 2 00203  10001        CLA   TEMP+1,2    GET 0 OR H/2          MARK0638
01156  0300 60 0 00243  10001        FAD*  L(T1)                            MARK0639
01157  0601 60 0 00243  10001        STO*  L(T1)                             MARK0640
01160  0131 00 0 00000  10000        XCA                                     MARK0641
01161  0300 60 0 00244  10001        FAD*  L(T2)                             MARK0642
01162  0300 60 0 00243  10001        FAD*  L(T1)                             MARK0643
01163  4600 60 0 00244  10001        STQ*  L(T2)                             MARK0644
01164  0601 60 0 00243  10001        STO*  L(T1)                             MARK0645
01165  0634 00 1 00404  10011        SXA   *+4,1                             MARK0646
01166  0634 00 2 00404  10011        SXA   *+4,2                             MARK0647
01167  0634 00 4 00404  10011        SXA   *+4,4                             MARK0648
01170  0522 00 2 00250  10001        XFC   DFR1,2      DO DFR1 OR DFR2       MARK0649
01171  0774 00 1 00000  10000        AXT   **,1                              MARK0650
01172  0774 00 2 00000  10000        AXT   **,2                              MARK0651
01173  0774 00 4 00000  10000        AXT   **,4                              MARK0652

BINARY CARD (NOT PUNCHED)
01174  2 00001 4 01145  10001        TIX   HK01,4,1    OUTER LOOP, DO 4      MARK0653
01175  0500 60 0 00243  10001        CLA*  L(T1)       NEW TIME IN BUFFER    MARK0654
01176  0560 60 0 00244  10001        LDQ*  L(T2)                             MARK0655
01177  0601 00 0 00240  10001        STO   T1                                MARK0656
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01200  4600 00 0 00241  10001          STQ     T2                                          MARK0657
01201  0774 00 1 00000  10000  HK08    AXT     **,1                                        MARK0658
01202  0774 00 2 00000  10000  HK09    AXT     **,2                                        MARK0659
01203  0774 00 4 00000  10000  HK10    AXT     **,4                                        MARK0660
01204  0020 00 4 00001  10000          TRA     1,4                                         MARK0661
01205  0601 60 0 05000  10011  HK02    STQ*    Y0(2)       K(I) STORAGE                    MARK0662
01206  0241 00 0 01246  10001          FDP     HK12                                        MARK0663
01207  0131 00 0 00000  10000          XCA                                                 MARK0664
01210  0300 60 0 04400  10011  HK06    FAD*    Y0                                          MARK0665
01211  0601 60 0 03000  10011          STQ*    Y           Y0 + K1/2, K2/2, K3             MARK0666
01212  0020 00 0 01154  10001          TRA     HK03                                        MARK0667
01213  0601 00 0 00204  10001  HK04    STQ     TEMP+2                                      MARK0668
01214  0131 00 0 00000  10000          XCA                                                 MARK0669
01215  0260 00 0 01246  10001          FMP     HK12                                        MARK0670
01216  0300 60 0 05000  10011          FAD*    Y0(2)                                       MARK0671

BINARY CARD (NOT PUNCHED)
01217  0601 60 0 05000  10011          STQ*    Y0(2)       K1 + 2 K2                       MARK0672
01220  0500 00 0 00204  10001          CLA     TEMP+2                                      MARK0673
01221  0020 00 0 01206  10001          TRA     HK02+1                                      MARK0674
01222  0601 00 0 00204  10001  HK05    STQ     TEMP+2                                      MARK0675
01223  0131 00 0 00000  10000          XCA                                                 MARK0676
01224  0260 00 0 01246  10001          FMP     HK12                                        MARK0677
01225  0300 60 0 05000  10011          FAD*    Y0(2)                                       MARK0678
01226  0601 60 0 05000  10011          STQ*    Y0(2)       K1 + 2 K2 + T K3                MARK0679
01227  0500 00 0 00204  10001          CLA     TEMP+2                                      MARK0680
01230  0020 00 0 01210  10001          TRA     HK06                                        MARK0681
01231  0300 60 0 05000  10011  HK07    FAD*    Y0(2)                                       MARK0682
01232  0241 00 0 01247  10001          FDP     HK13                                        MARK0683
01233  0131 00 0 00000  10000          XCA         (K1 + TK2 + TK3 + K4)/6                 MARK0684
01234  0300 60 0 04000  10011          FAD*    Y(2)                                        MARK0685
01235  0300 60 0 04400  10011          FAD*    Y0                                          MARK0686
01236  0601 60 0 03000  10011          STQ*    Y                                           MARK0687
01237  4600 60 0 04000  10011          STQ*    Y(2)                                        MARK0688
01240  0020 00 0 01154  10001          TRA     HK03                                        MARK0689
01241  0 00000 0 01205  10001          HK02                                                MARK0690

BINARY CARD (NOT PUNCHED)
01242  0 00000 0 01213  10001          HK04                                                MARK0691
01243  0 00000 0 01222  10001          HK05                                                MARK0692
01244  0 00000 0 01231  10001          HK07                                                MARK0693
01245  001000000000     10000  HK11    OCT     1000000000                                  MARK0694
01246  002400000000     10000  HK12    DEC     2.                                          MARK0695
01247  003600000000     10000  HK13    DEC     6.                                          MARK0696
01250  0020 00 0 01257  10001  ADAMS   TRA     ADAMS+7                                     MARK0697
01251  0020 00 0 00402  10011          TRA     *+2                                         MARK0698
01252  0761 00 0 00000  10000          NOP                                                 MARK0699
01253  0774 00 1 00400  10011          AXT     *,1                                         MARK0700
01254  0774 00 2 00400  10011          AXT     *,2                                         MARK0701
01255  0774 00 4 00400  10011          AXT     *,4                                         MARK0702
01256  0020 00 4 00001  10000          TRA     1,4         EXIT                            MARK0703
01257  0634 00 1 01253  10001          SXA     ADAMS+3,1                                   MARK0704
01260  0634 00 2 01254  10001          SXA     ADAMS+4,2                                   MARK0705
01261  0634 00 4 01255  10001          SXA     ADAMS+5,4                                   MARK0706
01262  4520 00 0 00251  10001          NZT     E                                           MARK0707
01263  0020 00 0 00406  10011          TRA     *+6                                         MARK0708
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01264  4520 00 0 01676  10001        NZT   A                                    MARK0709

BINARY CARD (NOT PUNCHED)
01265  0020 00 0 00404  10011        TRA   *+4                                  MARK0710
01266  0600 00 0 01676  10001        STZ   A                                    MARK0711
01267  0074 00 4 00414  10001        TSX   ABTB,4                               MARK0712
01270  0020 00 0 01127  10001        TRA   GT10+1                               MARK0713
01271  0074 00 4 01576  10001        TSX   GAINT,4                              MARK0714
01272  0 00000 0 00000  10000        PZE                                        MARK0715
01273  0500 00 0 01400  10011        CLA   HC                                   MARK0716
01274  0300 00 0 00240  10001        FAD   T1                                   MARK0717
01275  0601 00 0 00202  10001        STO   TEMP                                 MARK0718
01276  0131 00 0 00000  10000        XCA                                        MARK0719
01277  0300 00 0 00241  10001        FAD   T2                                   MARK0720
01300  0300 00 0 00202  10001        FAD   TEMP                                 MARK0721
01301  0601 00 0 00240  10001        STO   T1                                   MARK0722
01302  4600 00 0 00241  10001        STO   T2                                   MARK0723
01303  0601 60 0 00243  10001        STO*  L(I1)                                MARK0724
01304  4600 60 0 00244  10001        STO*  L(I2)                                MARK0725
01305  0522 00 0 00250  10001        XEC   DER1          TO DERIV BOX 1         MARK0726
01306  4520 00 0 00251  10001        NZT   E                                    MARK0727
01307  0020 00 0 01337  10001        TRA   RGUP                                 MARK0728

BINARY CARD (NOT PUNCHED)
01310  0534 00 1 00237  10001        LXA   (N),1                                MARK0729
01311  0534 00 2 00230  10001  RGET1 LXA   MP1,2          ERROR TEST 1           MARK0730
01312  0500 60 2 00273  10001        CLA*  DELX,2        SAVE YN,DELTA N        MARK0731
01313  0601 60 2 00323  10001        STO*  DELZ,2                               MARK0732
01314  2 00001 2 00402  10011        TIX   *-2,2,1                              MARK0733
01315  4520 00 0 00251  10001        NZT   E                                    MARK0734
01316  0020 00 0 00403  10011        TRA   *+3                                  MARK0735
01317  1 77777 2 00401  10011        TXI   *+1,2,-1                             MARK0736
01320  7 00000 2 00406  10011        TXL   *-6,2,0                              MARK0737
01321  0500 60 0 04400  10011        CLA*  Y0                                   MARK0738
01322  0601 60 0 00324  10001        STO*  YN                                   MARK0739
01323  0500 60 0 05000  10011        CLA*  Y0(2)                                MARK0740
01324  0601 60 0 00325  10001        STO*  YN2                                  MARK0741
01325  2 00001 1 01311  10001        TIX   RGET1,1,1                            MARK0742
01326  0500 00 0 03372  10001        CLA   RFIX1                                MARK0743
01327  0601 00 0 02000  10011        STO   NI                                   MARK0744
01330  0534 00 2 00230  10001        LXA   MP1,2                                MARK0745
01331  0500 00 2 01655  10001        CLA   GCOFP,2                              MARK0746
01332  0241 00 2 01666  10001        FDP   GCOFC-1,2                            MARK0747

BINARY CARD (NOT PUNCHED)
01333  0131 00 0 00000  10000        XCA                                        MARK0748
01334  0760 00 0 00003  10000        SSP                                        MARK0749
01335  0601 00 0 01670  10001        STO   RGA                                  MARK0750
01336  0020 00 0 01337  10001        TRA   RGUP                                 MARK0751
01337  0074 00 4 02663  10001  RGUP  TSX   UPDAT,4                             MARK0752
01340  0500 00 0 02000  10011        CLA   NI                                   MARK0753
01341  4100 00 0 01356  10001        TNZ   GND1          TO CORRECT             MARK0754
01342  0534 00 1 00237  10001  GND   LXA   (N),1                                MARK0755
01343  0500 60 0 03000  10011        CLA*  Y                                    MARK0756
01344  0601 60 0 04400  10011        STO*  Y0                                   MARK0757
01345  0500 60 0 04000  10011        CLA*  Y(2)                                 MARK0758
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01346  0601 60 0 05000  10011          STO*   Y0(2)                                  MARK0759
01347  2 00001 1 40404  10011          TIX    *-4,1,1                                MARK0760
01350  4520 00 0 00251  10001          NZT    E                                      MARK0761
01351  0020 00 0 00404  10011          TRA    *+4                                    MARK0762
01352  4520 00 0 01676  10001          NZT    A                                      MARK0763
01353  0020 00 0 00402  10011          TRA    *+2                                    MARK0764
01354  0074 00 4 03024  10001          TSX    X2.0,4                                 MARK0765
01355  0020 00 0 01253  10001          TRA    ADAMS+3        TO EXIT                 MARK0766

BINARY CARD (NOT PUNCHED)
01356  0601 00 0 00205  10001  GND1    STO    TEMP+3                                 MARK0767
01357  4120 00 0 00403  10011          TMI    *+3                                    MARK0768
01360  0500 00 0 01252  10001          CLA    ADAMS+2                                MARK0769
01361  0020 00 0 00402  10011          TRA    *+2                                    MARK0770
01362  0500 00 0 01251  10001          CLA    ADAMS+1                                MARK0771
01363  0601 00 0 01543  10001          STO    GFRK2                                  MARK0772
01364  0600 00 0 03023  10001          STZ    GZP                                    MARK0773
01365  0074 00 4 03007  10001          TSX    PUTB,4                                 MARK0774
01366  0534 00 1 00237  10001          LXA    (N),1                                  MARK0775
01367  0600 60 0 04400  10011          STZ*   Y0                                     MARK0776
01370  0600 60 0 05000  10011          STZ*   Y0(2)                                  MARK0777
01371  2 00001 1 40402  10011          TIX    *-2,1,1                                MARK0778
01372  0074 00 4 01576  10001          TSX    GAINT,4        CORRECT                 MARK0779
01373  000000077777     10000          OCT    77777                                  MARK0780
01374  4754 00 0 00000  10000          PXD    0,0                                    MARK0781
01375  0534 00 1 00240  10001          LXA    MP1,1                                  MARK0782
01376  0300 00 1 01667  10001          FAD    GCOFC,1        SUM M+1 COEFF           MARK0783
01377  2 00001 1 40401  10011          TIX    *-1,1,1                                MARK0784
01400  0601 00 0 00256  10001          STO    GSIGM                                  MARK0785

BINARY CARD (NOT PUNCHED)
01401  0522 00 0 00247  10001  GLP     XEC    DER2           TIME UNCH D.E.          MARK0786
01402  0534 00 4 00230  10001          LXA    MP1,4                                  MARK0787
01403  0534 00 1 00237  10001          LXA    (N),1                                  MARK0788
01404  0500 60 0 03400  10011          CLA*   YDOT                                   MARK0789
01405  0302 60 4 00273  10001          FSB*   DELX,4                                 MARK0790
01406  0302 60 0 05000  10011          FSB*   Y0(2)                                  MARK0791
01407  0601 60 0 04400  10011          STO*   Y0                                     MARK0792
01410  0300 60 0 05000  10011          FAD*   Y0(2)                                  MARK0793
01411  0601 60 0 05000  10011          STO*   Y0(2)                                  MARK0794
01412  2 00001 1 40406  10011          TIX    *-6,1,1                                MARK0795
01413  4520 00 0 00251  10001          NZT    E              AEC TEST 2              MARK0796
01414  0020 00 0 01543  10001          TRA    GFRK2                                  MARK0797
01415  0600 00 0 10000  10011          STZ    RGERR          FRROR TEST 2            MARK0798
01416  0600 00 0 01673  10001          STZ    RGYPC                                  MARK0799
01417  0534 00 1 00237  10001          LXA    (N),1                                  MARK0800
01420  0500 60 0 03000  10011  RG1     CLA*   Y                                      MARK0801
01421  0760 00 0 00003  10000          SSP                                           MARK0802
01422  0340 00 0 07400  10011          UAS    YCLOW                                  MARK0803
01423  0020 00 0 00403  10011          TRA    *+3                                    MARK0804

BINARY CARD (NOT PUNCHED)
01424  0020 00 0 00402  10011          TRA    *+2                                    MARK0805
01425  0500 00 0 07400  10011          CLA    YCLOW                                  MARK0806
01426  0601 00 0 01672  10001          STO    RGDI                                   MARK0807
01427  0074 00 4 01677  10001          TSX    RGMAX,4                                MARK0808
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01430  0760 00 0 00003  10000        SSP                                  MARK0809
01431  0241 00 0 01672  10001        FDP   RGDI                           MARK0810
01432  0131 00 0 00000  10000        XCA                                  MARK0811
01433  0340 00 0 01673  10001        CAS   RGYPC                          MARK0812
01434  0020 00 0 00403  10011        IRA   *+3                            MARK0813
01435  0020 00 0 00402  10011        IRA   *+2                            MARK0814
01436  0500 00 0 01673  10001        CLA   RGYPC                          MARK0815
01437  0601 00 0 01673  10001        STO   RGYPC                          MARK0816
01440  0241 00 0 01670  10001        FDP   RGA                            MARK0817
01441  0500 00 0 10000  10011        CLA   RGERR                          MARK0818
01442  0040 00 0 00402  10011        TLQ   *+2                            MARK0819
01443  4600 00 0 10000  10011        STQ   RGERR                          MARK0820
01444  2 00001 1 01420  10001        ITX   RG1*1,1                        MARK0821
01445  0500 00 0 10000  10011        CLA   RGERR                          MARK0822
01446  0340 00 0 06000  10011        CAS   ELBAR                          MARK0823

BINARY CARD (NOT PUNCHED)
01447  0020 00 0 01463  10001        IRA   RG3                            MARK0824
01450  0020 00 0 00401  10011        IRA   *+1                            MARK0825
01451  0520 00 0 00252  10001        ZET   HD                             MARK0826
01452  0020 00 0 01543  10001        IRA   GFRK2                          MARK0827
01453  0500 00 0 01400  10011        CLA   HC                             MARK0828
01454  0300 00 0 01400  10011        FAD   HC                             MARK0829
01455  0340 00 0 06400  10011        CAS   HMAXT                          MARK0830
01456  0020 00 0 01543  10001        IRA   GFRK2                          MARK0831
01457  0020 00 0 01543  10001        IRA   GFRK2                          MARK0832
01460  0500 00 0 00400  10011        CLA   *                              MARK0833
01461  0601 00 0 01676  10001        STO   A                              MARK0834
01462  0020 00 0 01543  10001        IRA   GFRK2                          MARK0835
01463  0500 00 0 10000  10011  RG3   CLA   RGERR                          MARK0836
01464  0340 00 0 05400  10011        CAS   EUBAR                          MARK0837
01465  0020 00 0 01470  10001        IRA   RGX*2                          MARK0838
01466  0020 00 0 01543  10001        IRA   GFRK2                          MARK0839
01467  0020 00 0 01543  10001        IRA   GFRK2                          MARK0840
01470  0560 00 0 01400  10011  RGX*2 LDQ   HC                             MARK0841
01471  0260 00 0 01653  10001        FMP   GCOFP-2       0.5 DELTA T      MARK0842

BINARY CARD (NOT PUNCHED)
01472  0340 00 0 07000  10011        CAS   HMINT                          MARK0843
01473  0020 00 0 00403  10011        IRA   *+3                            MARK0844
01474  0020 00 0 01543  10001        IRA   GFRK2                          MARK0845
01475  0020 00 0 01543  10001        IRA   GFRK2                          MARK0846
01476  0500 00 0 03372  10001        CLA   REIX1         HALVE            MARK0847
01477  0601 00 0 00233  10001        STO   NH                             MARK0848
01500  0502 00 0 01400  10011        CLS   HC                             MARK0849
01501  0300 00 0 00240  10001        FAD   T1                             MARK0850
01502  0601 00 0 00202  10001        STO   TEMP                           MARK0851
01503  0131 00 0 00000  10000        XCA                                  MARK0852
01504  0300 00 0 00241  10001        FAD   T2                             MARK0853
01505  0300 00 0 00202  10001        FAD   TEMP                           MARK0854
01506  0601 00 0 00240  10001        STO   T1                             MARK0855
01507  4600 00 0 00241  10001        STQ   T2                             MARK0856
01510  0601 60 0 00243  10001        STO*  L(T1)                          MARK0857
01511  4600 60 0 00244  10001        STQ*  L(T2)         RESTORE TN       MARK0858
01512  0534 00 1 00237  10001        LXA   (N)*1                          MARK0859
01513  0774 00 4 00002  10000  RG4   AXT   2,4                            MARK0860
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01514  0534 00 2 00230  10001        LXA    MP1,2                                    MARK0861

BINARY CARD (NOT PUNCHED)
01515  0500 60 2 00323  10001        CLA*   DELZ,2                                   MARK0862
01516  0601 60 2 00273  10001        STO*   DELX,2                                   MARK0863
01517  6 00001 4 00402  10011        TNX    **2,4,1                                  MARK0864
01520  0601 60 0 03400  10011        STO*   YDOT                                     MARK0865
01521  2 00001 2 40404  10011        TIX    *-4,2,1                                  MARK0866
01522  1 77777 2 00401  10011        TXI    **1,2,-1                                 MARK0867
01523  7 00000 2 40406  10011        TXL    *-6,2,0                                  MARK0868
01524  0500 60 0 00324  10001        CLA*   YN                                       MARK0869
01525  0601 60 0 04400  10011        STO*   Y0                                       MARK0870
01526  0601 60 0 03000  10011        STO*   Y                                        MARK0871
01527  0500 60 0 00325  10001        CLA*   YN2                                      MARK0872
01530  0601 60 0 05000  10011        STO*   Y0(2)                                    MARK0873
01531  0601 60 0 04000  10011        STO*   Y(2)                                     MARK0874
01532  2 00001 1 01513  10001        TIX    RG4,1,1                                  MARK0875
01533  0522 00 0 00216  10001        XEC    AEOS                                     MARK0876
01534  0600 00 0 00234  10001        STZ    ND                                       MARK0877
01535  0600 00 0 00252  10001        STZ    HD                                       MARK0878
01536  0500 00 0 03157  10001        CLA    RB1G                                     MARK0879
01537  0601 00 0 00221  10001        STO    TRG2                                     MARK0880

BINARY CARD (NOT PUNCHED)
01540  0074 00 4 00414  10001        TSX    ARTB,4     FIND NEW TMIN                 MARK0881
01541  0020 00 0 01127  10001        TRA    GT10+1     ERROR RETURN                  MARK0882
01542  0020 00 0 00752  10001        TRA    GT2+1                                    MARK0883
01543  0761 00 0 00000  10000  GERK2 NOP                                             MARK0884
01544  0534 00 2 00205  10001        LXA    TEMP+3,2                                 MARK0885
01545  1 77777 2 00401  10011        TXI    **1,2,-1                                 MARK0886
01546  0634 00 2 00205  10001        SXA    TEMP+3,2                                 MARK0887
01547  3 00000 2 00402  10011        TXH    **2,2,0                                  MARK0888
01550  0020 00 0 01565  10001        TRA    GADN-2                                   MARK0889
01551  0534 00 1 00237  10001        LXA    (N),1      FORM NEXT ITERATE             MARK0890
01552  0560 00 0 01400  10011        LDQ    HC                                       MARK0891
01553  0260 00 0 00256  10001        FMP    GSIGM                                    MARK0892
01554  0601 00 0 00203  10001        STO    TEMP+1                                   MARK0893
01555  0560 00 0 00203  10001        LDQ    TEMP+1                                   MARK0894
01556  0260 60 0 04400  10011        FMP*   Y0                                       MARK0895
01557  0300 60 0 04000  10011        FAD*   Y(2)                                     MARK0896
01560  0300 60 0 03000  10011        FAD*   Y                                        MARK0897
01561  0601 60 0 03000  10011        STO*   Y                                        MARK0898
01562  4600 60 0 04000  10011        STQ*   Y(2)                                     MARK0899

BINARY CARD (NOT PUNCHED)
01563  2 00001 1 40406  10011        TIX    *-6,1,1                                  MARK0900
01564  0020 00 0 01401  10001        TRA    GLP                                      MARK0901
01565  0761 00 0 00000  10000        NOP                                             MARK0902
01566  0534 00 2 00230  10001        LXA    MP1,2      FIXED ITERATIONS END          MARK0903
01567  0534 00 1 00237  10001  GADN  LXA    (N),1                                    MARK0904
01570  0500 60 0 05000  10011        CLA*   Y0(2)                                    MARK0905
01571  0300 60 2 00273  10001        FAD*   DELX,2                                   MARK0906
01572  0601 60 2 00273  10001        STO*   DELX,2                                   MARK0907
01573  2 00001 1 40403  10011        TIX    *-3,1,1                                  MARK0908
01574  2 00001 2 40405  10011        TIX    *-5,2,1    DIFF TABLE UPDATED            MARK0909
01575  0020 00 0 01342  10001        TRA    GND        TO EXIT                       MARK0910
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01576  0020 00 0 00007  10011  GAINT TRA   *+7      PREDICTOR-CORRECTOR SR      MARK0911
01577  0 00000 0 01655  10001        PZE   GCOFP    CALL SFQ                    MARK0912
01600  0 00000 0 01657  10001        PZE   GCOFC    TSX GAINT,4                 MARK0913
01601  0774 00 1 00400  10011        AXT   *,1      PZE K                       MARK0914
01602  0774 00 2 00400  10011        AXT   *,2      NOR RET                     MARK0915
01603  0774 00 4 00400  10011        AXT   *,4      IF K=0,PREDICT              MARK0916
01604  0020 00 4 00002  10000        TRA   2,4      IF K NOT 0,CORRECT          MARK0917
01605  0634 00 1 01601  10001        SXA   GAINT+3,1                            MARK0918

BINARY CARD (NOT PUNCHED)
01606  0634 00 2 01602  10001        SXA   GAINT+4,2                            MARK0919
01607  0634 00 4 01603  10001        SXA   GAINT+5,4                            MARK0920
01610  0500 00 4 00001  10000        CLA   1,4                                  MARK0921
01611  0100 00 0 00003  10011        FZE   *+3                                  MARK0922
01612  0500 00 0 01600  10001        CLA   GAINT+2                              MARK0923
01613  0020 00 0 00002  10011        TRA   *+2                                  MARK0924
01614  0500 00 0 01577  10001        CLA   GAINT+1                              MARK0925
01615  0621 00 0 00005  10011        STA   *+5                                  MARK0926
01616  0534 00 1 00237  10001        LXA   (N),1                                MARK0927
01617  0534 00 2 00230  10001        LXA   MP1,2                                MARK0928
01620  0774 00 4 00001  10000        AXT   1,4                                  MARK0929
01621  0600 00 0 00202  10001        STZ   TEMP                                 MARK0930
01622  0560 00 4 00400  10011        LDQ   *,4                                  MARK0931
01623  0260 60 2 00273  10001        FMP*  DELX,2                               MARK0932
01624  0300 00 0 00202  10001        FAD   TEMP                                 MARK0933
01625  0601 00 0 00202  10001        STQ   TEMP                                 MARK0934
01626  1 00001 4 00401  10011        TXI   *+1,4,1                              MARK0935
01627  2 00001 2 00405  10011        TIX   *-5,2,1                              MARK0936
01630  0131 00 0 00000  10000        XCA                                        MARK0937

BINARY CARD (NOT PUNCHED)
01631  0260 00 0 01400  10011        FMP   HC                                   MARK0938
01632  0300 60 0 03000  10011        FAD*  Y                                    MARK0939
01633  0601 00 0 00202  10001        STQ   TEMP                                 MARK0940
01634  0131 00 0 00000  10000        XCA                                        MARK0941
01635  0300 60 0 04000  10011        FAD*  Y(2)                                 MARK0942
01636  0300 00 0 00202  10001        FAD   TEMP                                 MARK0943
01637  0601 60 0 03000  10011        STQ*  Y                                    MARK0944
01640  4600 60 0 04000  10011        STQ*  Y(2)                                 MARK0945
01641  2 00001 1 40422  10011        TIX   *-18,1,1                             MARK0946
01642  0020 00 0 01601  10001        TRA   GAINT+3          TO EXIT             MARK0947
01643  177445756155     10000        DEC   0.2870754484                         MARK0948
01644  177455743603     10000        DEC   0.294868003                          MARK0949
01645  177467415215     10000        DEC   0.304224539                          MARK0950
01646  177503125041     10000        DEC   0.315591936                          MARK0951
01647  177521616162     10000        DEC   0.329861111                          MARK0952
01650  177544764477     10000        DEC   0.348611111                          MARK0953
01651  177600000000     10000        DEC   0.375                                MARK0954
01652  177652525252     10000        DEC   0.416666666                          MARK0955
01653  200400000000     10000        DEC   0.5                                  MARK0956

BINARY CARD (NOT PUNCHED)
01654  201400000000     10000        DEC   1.0                                  MARK0957
01655  572402477654     10000  GCOFP DEC   -0.0078925542                        MARK0958
01656  572462460502     10000        DEC   -0.0093565362                        MARK0959
01657  572564371174     10000        DEC   -0.0113673950                        MARK0960
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01660  572723445067  10000        DEC   -0.0142691795                                  MARKn961
01661  573465146315  10000        DEC   -0.1875E-1                                     MARKn962
01662  573660266026  10000        DEC   -0.2638888888E-1                               MARKn963
01663  574525252525  10000        DEC   -0.416666666E-1                                MARKn964
01664  575525252525  10000        DEC   -0.833333333E-1                                MARKn965
01665  600400000000  10000        DEC   -0.5                                           MARKn966
01666  201400000000  10000        DEC   1.0                                            MARKn967
01667  0 00000 0 00000  10000 GCOFC  PZE                                               MARKn968
01670  0 00000 0 00000  10000   KGA  PZE                 COEFF. FOR ERROR DETER.       MARKn969
01671  0 00000 0 00000  10000 KGERR  PZE                 F(N+1)                        MARKn970
01672  0 00000 0 00000  10000  RGDI  PZE           /D(I)/                              MARKn971
01673  200000000003     00001 KGYPC  BSS   3                                           MARKn972
01676  0 00000 0 00000  10000     A  PZE   0          FLAG WORD FOR TURNING ON DOUBLING(AEC)  MARKn973
01677  0634 00 4 01726  10001 KGMAX  SXA   KGMX,4                                      MARKn974
01700  0634 00 2 01727  10001        SXA   KGMX+1,2                                    MARKn975

BINARY CARD (NOT PUNCHED)
01701  0534 00 2 00230  10001        LXA   MP1,2                                       MARKn976
01702  0774 00 4 00001  10000        AXT   1,4                                         MARKn977
01703  0600 00 0 01674  10001        STZ   KGYPC+1                                     MARKn978
01704  0560 00 4 01667  10001        LDQ   GCOFC,4                                     MARKn979
01705  0260 60 2 00273  10001        FMP*  DELX,2                                      MARKn980
01706  0300 00 0 01674  10001        FAD   KGYPC+1                                     MARKn981
01707  0601 00 0 01674  10001        STO   KGYPC+1                                     MARKn982
01710  1 00001 4 00401  10011        TXI   *+1,4,1                                     MARKn983
01711  2 00001 2 40405  10011        TIX   *-5,2,1                                     MARKn984
01712  0534 00 2 00230  10001        LXA   MP1,2                                       MARKn985
01713  0774 00 4 00001  10000        AXT   1,4                                         MARKn986
01714  0600 00 0 01675  10001        STZ   KGYPC+2                                     MARKn987
01715  0560 00 4 01655  10001        LDQ   GCOFP,4                                     MARKn988
01716  0260 60 2 00323  10001        FMP*  DELZ,2                                      MARKn989
01717  0300 00 0 01675  10001        FAD   KGYPC+2                                     MARKn990
01720  0601 00 0 01675  10001        STO   KGYPC+2                                     MARKn991
01721  1 00001 4 00401  10011        TXI   *+1,4,1                                     MARKn992
01722  2 00001 2 40405  10011        TIX   *-5,2,1                                     MARKn993
01723  0302 00 0 01674  10001        FSB   KGYPC+1                                     MARKn994

BINARY CARD (NOT PUNCHED)
01724  0131 00 0 00000  10000        XCA                                               MARKn995
01725  0260 00 0 01400  10011        FMP   HC                                         MARKn996
01726  0774 00 4 00000  10000  KGMX  AXT   0,4                                         MARKn997
01727  0774 00 2 00000  10000        AXT   0,2                                         MARKn998
01730  0020 00 4 00001  10000        TRA   1,4                                         MARKn999
01731  0634 00 1 01770  10001  FLAG  SXA   OOP,1          SAVE INDEX 1               MARK1000
01732  0634 00 2 01771  10001        SXA   OUCH,2         SAVE INDEX 2               MARK1001
01733  0634 00 4 01765  10001        SXA   OUT,4          SAVE INDEX 4               MARK1002
01734  0774 00 2 00062  10000        AXT   OMAR,2                                     MARK1003
01735  0534 00 4 00231  10001        LXA   I4,4           INDEX FROM TSX MARK,4      MARK1004
01736  0600 00 0 02031  10001        STZ   ORGY                                      MARK1005
01737  0500 00 4 00004  10000  OMNI  CLA   4,4                                       MARK1006
01740  0100 00 0 01765  10001        TZE   OUT            LAST TRIGGER               MARK1007
01741  4120 00 0 01761  10001        TMI   OMER           IGNORE NEGATIVE TRIGGERS   MARK1008
01742  4737 00 1 00000  10000        PDC   ,1             ADDRESS IN INDEX1          MARK1009
01743  7 00000 1 01761  10001        IXL   OMER,1,0       IGNORE TIME STOPS          MARK1010
01744  0500 00 1 00000  10000        CLA   0,1            YSUBJ                      MARK1011
01745  0302 60 4 00005  10000        FSB*  5,4                                       MARK1012
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01746  0601 00 0 00202  10001        STO    TEMP                                    MARK1013

BINARY CARD (NOT PUNCHED)
01747  4120 00 0 01773  10001        TM1    OREY    SIGN OF DIFFERENCE TEST         MARK1014
01750  0500 00 0 02032  10001        CLA*   L       YSUBJ-ZSUBJ AT TL               MARK1015
01751  0120 00 0 01775  10001        TPL    OINK    IF SAME SIGN IGNORE             MARK1016
01752  0500 00 0 00202  10001  OZONE CLA    TEMP                                    MARK1017
01753  0601 00 0 02033  10001        STO*   R       RDEWJ FOR FLAG                  MARK1018
01754  0601 00 0 02034  10001        STO*   W                                       MARK1019
01755  0500 00 0 01751  10001        CLA    FLAG                                    MARK1020
01756  0625 00 0 02031  10001        STI    ORGY    TEST FOR FLAG RETURN            MARK1021
01757  0625 00 4 00004  10000  ODEN STI    4,4     FLAG                            MARK1022
01760  1 77777 2 00401  10011        TX1    *+1,2,-1                                MARK1023
01761  1 77776 4 00401  10011  OMER TX1    *+1,4,-2                                MARK1024
01762  3 00000 2 01737  10001        TXH    OMNI,2,0                                MARK1025
01763  0534 00 4 00231  10001        LXA    14,4    ERROR RETURN FOR TOO MANY       MARK1026
01764  0020 00 4 00003  10000        IRA    3,4                                     MARK1027
01765  0774 00 4 00000  10000  OUT   AXT    ,4      DEPENDENT VARIABLE STOPS        MARK1028
01766  0520 00 0 02031  10001        ZET    ORGY    IF ZERO                         MARK1029
01767  1 77777 4 01770  10001        TX1    OOP,4,-1                                MARK1030
01770  0774 00 1 00000  10000  OOP   AXT    ,1      OTHERWISE NORMAL                MARK1031
01771  0774 00 2 00000  10000  OOCH  AXT    ,2                                      MARK1032

BINARY CARD (NOT PUNCHED)
01772  0020 00 4 00001  10000        IRA    1,4                                     MARK1033
01773  0500 00 0 02032  10001  OREY  CLA*   L       YSUBJ-ZSUBJ AT TL               MARK1034
01774  0120 00 0 01752  10001        TPL    OZONE   SET FLAG IF SIGN NOT EQUAL      MARK1035
01775  0500 00 0 00400  10011  OINK  CLA    *       OTHERWISE CLEAR TAG             MARK1036
01776  0020 00 0 01757  10001        IRA    ODEN    AND CONTINUE                    MARK1037
01777  0634 00 4 02025  10001  SET   SXA    ORIT,4  SAVE INDEX 4                    MARK1038
02000  0634 00 2 02027  10001        SXA    OOZE,2  SAVE INDEX 2                    MARK1039
02001  0634 00 1 02026  10001        SXA    ODE,1   SAVE INDEX 1                    MARK1040
02002  0534 00 4 00231  10001        LXA    14,4                                    MARK1041
02003  0774 00 2 00002  10000        AXT    OMAR,2                                  MARK1042
02004  0500 00 0 00240  10001        CLA    T1                                      MARK1043
02005  0601 00 0 00176  10001        STO    TL                                      MARK1044
02006  0500 00 0 00241  10001        CLA    T2      OR                              MARK1045
02007  0601 00 0 00177  10001        STO    TL2     OTHERWISE                       MARK1046
02010  0500 00 4 00004  10000  OVER  CLA    4,4                                     MARK1047
02011  0100 00 0 02025  10001        TZE    ORIT    LAST TRIGGER                    MARK1048
02012  4120 00 0 02021  10001        TM1    OMEN    IGNORE NEGATIVE TRIGGER         MARK1049
02013  4737 00 1 00000  10000        PDC    ,1                                      MARK1050
02014  7 00000 1 02021  10001        TXL    OMEN,1,0  IGNORE TIME STOPS             MARK1051

BINARY CARD (NOT PUNCHED)
02015  0500 00 1 00000  10000        CLA    0,1     YSUBJ                           MARK1052
02016  0502 00 4 00005  10000        FSB*   5,4                                     MARK1053
02017  0601 00 0 02032  10001        STO*   L       YSUBJ-ZSUBJ                     MARK1054
02020  1 77777 2 00401  10011        TX1    *+1,2,-1                                MARK1055
02021  1 77776 4 02022  10001  OMEN  TX1    OPINE,4,-2                              MARK1056
02022  3 00000 2 02010  10001  OPINE TXH    OVER,2,0                                MARK1057
02023  0534 00 4 00231  10001        LXA    14,4    ERROR RETURN FOR TOO MANY       MARK1058
02024  1 77776 4 02026  10001        TX1    ODE,4,-2  DEPENDENT VARIABLE STOPS      MARK1059
02025  0774 00 4 00000  10000  ORIT  AXT    ,4                                      MARK1060
02026  0774 00 1 00000  10000  ODE   AXT    ,1                                      MARK1061
02027  0774 00 2 00000  10000  OOZE  AXT    ,2                                      MARK1062
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02030  0020 00 4 00001  10000          TRA    1,4                                    MARK1063
02031  0 00000 0 00000  10000  ORGT    PZE                    TAG STORAGE             MARK1064
02032  0 00000 2 02117  10001      L   PZE    LTAB+OMAR,2                            MARK1065
02033  0 00000 2 02201  10001      R   PZE    RTAB+OMAR,2                            MARK1066
02034  0 00000 2 02203  10001      W   PZE    WTAB+OMAR,2                            MARK1067
02035  200000000062     00001  LTAB  BSS    OMAR                                   MARK1069
02117  200000000062     00001  RTAB  BSS    OMAR                                   MARK1070
02201  200000000062     00001  WTAB  BSS    OMAR                                   MARK1071

BINARY CARD (NOT PUNCHED)
02263  0634 00 4 02376  10001  SRCH  SXA    OBOY,4   SAVE INDEX 4                  MARK1072
02264  0634 00 2 02451  10001        SXA    OVAL,2   SAVE INDEX 2                  MARK1073
02265  0634 00 1 02377  10001        SXA    ORB,1    SAVE INDEX 1                  MARK1074
02266  0500 00 0 02440  10001        CLA    ORESE                                  MARK1075
02267  0601 00 0 02436  10001        STO    OGEE     HM=BIG                        MARK1076
02270  0601 00 0 02437  10001        STO    HP                                     MARK1077
02271  0534 00 4 00201  10001        LXA    14,4     INDEX FROM TSX MARK,4         MARK1078
02272  0774 00 2 00062  10000        AXT    OMAR,2                                 MARK1079
02273  0500 00 4 00004  10000  ONSET CLA    4,4                                    MARK1080
02274  0100 00 0 02376  10001        LZE    OBOY     LAST TRIGGER                  MARK1081
02275  4120 00 0 02372  10001        TMI    OMIT     OMIT NEGATIVE TRIGGERS        MARK1082
02276  4737 00 1 00000  10000        PDC    0,1                                    MARK1083
02277  7 00000 1 02372  10001        TXL    OMIT,1,0 OMIT INDEPENDENT STOPS        MARK1084
02300  0625 00 0 02031  10001        STT    ORGY                                   MARK1085
02301  4520 00 0 02031  10001        NZT    ORGY     TEST WORD                     MARK1086
02302  0020 00 0 02371  10001        TRA    ODOR     EQUAL ZERO                    MARK1087
02303  0500 00 1 00000  10000        CLA    0,1      NOT EQUAL ZERO                MARK1088
02304  0302 00 4 00005  10000        FSB*   5,4                                    MARK1089
02305  0601 00 0 02034  10001        STO*   W        WSUBJ=YSUBJ-ZSUBJ             MARK1090

BINARY CARD (NOT PUNCHED)
02306  0302 00 0 02032  10001        FSB*   L                                      MARK1091
02307  0601 00 0 00204  10001        STO    TEMP+2                                 MARK1092
02310  4500 00 0 02034  10001        CAL*   W                                      MARK1093
02311  0322 00 0 02032  10001        ERA*   L                                      MARK1094
02312  4760 00 0 00001  10000        PBT                                           MARK1095
02313  0020 00 0 02343  10001        TRA    REACH    EQUAL SIGN SGN WJ=SGN LJ      MARK1096
02314  0634 00 4 02321  10001        SXA    OVARY,4  OPPOSITE IN SIGN              MARK1097
02315  0634 00 2 02320  10001        SXA    OVARY-1,2                              MARK1098
02316  0074 00 4 02716  10001        TSX    DSUB,4                                 MARK1099
02317  0 00240 0 00176  10101        PZE    TL,,T1                                 MARK1100
02320  0774 00 2 00000  10000        AXT    **,2                                   MARK1101
02321  0774 00 4 00000  10000  OVARY AXT    **,4                                   MARK1102
02322  0241 00 0 00204  10001        FDP    TEMP+2   (TL-T)/(WJ-LJ)                MARK1103
02323  0260 00 0 02034  10001        FMP*   W                                      MARK1104
02324  0601 00 0 00202  10001        STO    TEMP     R                             MARK1105
02325  0500 00 0 02436  10001        CLA    OGEE     HM                            MARK1106
02326  0560 00 0 00202  10001        LDQ    TEMP     R                             MARK1107
02327  0040 00 0 00402  10011        TLQ    *+2                                    MARK1108
02330  0020 00 0 02342  10001        TRA    RSTOR                                  MARK1109

BINARY CARD (NOT PUNCHED)
02331  4600 00 0 02436  10001        STQ    OGEE     R LESS THAN HM                MARK1110
02332  0500 00 0 00202  10001  RSTOR CLA    TEMP                                   MARK1111
02333  0760 00 0 00003  10000        SSP                                           MARK1112
02334  0302 00 0 00175  10001        FSB    DELU                                   MARK1113
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02335  0120 00 0 02340  10001        TPL    OCCUR                                  MARK1114
02336  0500 00 0 02441  10001        CLA    OFT                                    MARK1115
02337  0020 00 0 02341  10001        TRA    ONION                                  MARK1116
02340  0500 00 0 02337  10001  OCCUR CLA    ORB                                    MARK1117
02341  0625 00 4 00004  10000  ONION STT    4,4                                    MARK1118
02342  0020 00 0 02371  10001        TRA    ODOR                                   MARK1119
02343  4500 60 0 02034  10001  REACH CAL*   W                                      MARK1120
02344  0322 60 0 02033  10001        ERA*   R                                      MARK1121
02345  4760 00 0 00001  10000        PBT                                           MARK1122
02346  0020 00 0 02367  10001        TRA    RFLAG          SGN WJ=SGN RJ          MARK1123
02347  0500 60 0 02034  10001        CLA*   W                                      MARK1124
02350  0302 60 0 02033  10001        FSB*   R                                      MARK1125
02351  0601 00 0 00204  10001        STO    TEMP+2         WJ-RJ                  MARK1126
02352  0634 00 2 00404  10011        SXA    **+2,2                                MARK1127
02353  0634 00 4 00404  10011        SXA    **+2,4                                MARK1128

BINARY CARD (NOT PUNCHED)
02354  0074 00 4 02716  10001        TSX    DSUB,4                                 MARK1129
02355  0 00240 0 00200  10101        PZE    TR,,T1                                 MARK1130
02356  0774 00 2 00000  10000        AXT    **,2                                   MARK1131
02357  0774 00 4 00000  10000        AXT    **,4                                   MARK1132
02360  0241 00 0 00204  10001        FDP    TEMP+2         (TR-T)/(WJ-RJ)         MARK1133
02361  0260 60 0 02034  10001        FMP*   W                                      MARK1134
02362  0601 00 0 00202  10001        STO    TEMP                                   MARK1135
02363  0560 00 0 02437  10001        LDQ    HP                                     MARK1136
02364  0040 00 0 02332  10001        TLQ    RSTOR                                  MARK1137
02365  0601 00 0 02437  10001        STO    HP                                     MARK1138
02366  0020 00 0 02332  10001        TRA    RSTOR                                  MARK1139
02367  0500 00 0 00400  10011  RFLAG CLA    *                                      MARK1140
02370  0625 00 4 00004  10000        STT    4,4                                    MARK1141
02371  1 77777 2 00401  10011  ODOR  TXI    **+1,2,-1                              MARK1142
02372  1 77776 4 00401  10011  OMIT  TXI    **+1,4,-2                              MARK1143
02373  3 00000 2 02273  10001        TXH    ONSET,2,0                              MARK1144
02374  0534 00 4 00231  10001        LXA    14,4                                   MARK1145
02375  0020 00 4 00003  10000        TRA    3,4            ERROR RETURN (TOO MANY DEPEND. VAR TRIMARK1146
02376  0774 00 4 00000  10000  OBOY  AXT    **,4                                   MARK1147

BINARY CARD (NOT PUNCHED)
02377  0774 00 1 00000  10000  ORB   AXT    **,1                                   MARK1148
02400  0500 00 0 02436  10001        CLA    OBEE                                   MARK1149
02401  0302 00 0 02440  10001        FSB    OBESE                                  MARK1150
02402  4100 00 0 02415  10001        TNZ    RSTRJ                                  MARK1151
02403  0774 00 2 00062  10000        AXT    OMAR,2                                 MARK1152
02404  0500 60 0 02034  10001        CLA*   W                                      MARK1153
02405  0601 60 0 02032  10001        STO*   L              LJ=WJ                  MARK1154
02406  2 00001 2 40402  10011        TIX    *-2,2,1                                MARK1155
02407  0500 00 0 00240  10001        CLA    T1                                     MARK1156
02410  0560 00 0 00241  10001        LDQ    I2                                     MARK1157
02411  0601 00 0 00176  10001        STO    IL                                     MARK1158
02412  4600 00 0 00177  10001        STQ    IL2                                    MARK1159
02413  0500 00 0 02437  10001        CLA    HP                                     MARK1160
02414  0020 00 0 02426  10001        TRA    RSTOT                                  MARK1161
02415  0774 00 2 00062  10000  RSTRJ AXT    OMAR,2                                 MARK1162
02416  0500 60 0 02034  10001        CLA*   W                                      MARK1163
02417  0601 60 0 02033  10001        STO*   R              RJ=WJ                  MARK1164
02420  2 00001 2 40402  10011        TIX    *-2,2,1                                MARK1165
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02421  0500 00 0 00240  10001        CLA    T1                                  MARK1166

BINARY CARD (NOT PUNCHED)
02422  0560 00 0 00241  10001        LDQ    T2                                  MARK1167
02423  0601 00 0 00200  10001        STO    TR                                  MARK116A
02424  4600 00 0 00201  10001        STQ    TR2                                 MARK1169
02425  0500 00 0 02436  10001        CLA    OGEE                                MARK1170
02426  0601 00 0 00253  10001  KSTOT STO    HIC                                 MARK1171
02427  0760 00 0 00003  10000        SSP                                        MARK1172
02430  0560 00 0 00175  10001        LDQ    DELU                                MARK1173
02431  0774 00 2 00000  10000  OVAL  AXT    **,2                                MARK1174
02432  0040 00 0 00402  10011        TLQ    *+2                                 MARK1175
02433  0020 00 4 00001  10000        TRA    1,4                                 MARK1176
02434  0500 00 0 00253  10001        CLA    HIC                                 MARK1177
02435  0020 00 4 00002  10000        TRA    2,4                                 MARK1178
02436  0 00000 0 00000  10000  OGEE  PZE    HM                                  MARK1179
02437  0 00000 0 00000  10000  HP    PZE                                        MARK1180
02440  377777777777     10000  OBESE OCT    377777777777                        MARK1181
02441  0 00000 5 00000  10000  OFT   PZE    ,5                                  MARK1182
                                   INTERPOLATION ROUTINE FOR ADAMS-MOULTON (MARK) MARK1183
                                   TSX INTRP,4                                 MARK1184
                                   NORMAL RETURN                               MARK1185
02442  0634 00 4 02551  10001  INTRP SXA    RICH,4          ENTER              MARK1186
02443  0634 00 1 02552  10001        SXA    RICH+1,1                           MARK1187
02444  0634 00 2 02553  10001        SXA    RICH+2,2                           MARK1188

BINARY CARD (NOT PUNCHED)
02445  0074 00 4 02716  10001        TSX    DSUB,4                              MARK1189
02446  0 00240 0 02400  10111        PZE    TGO*,T1                             MARK1190
02447  0601 00 0 02575  10001        STO    RIMU-1          HC(MU)              MARK1191
02450  0241 00 0 01400  10011        FDP    HC                                  MARK1192
02451  4600 00 0 02576  10001        STQ    RIM             MU                  MARK1193
02452  0534 00 2 02463  10001        LXA    RLOC1+3,2       IR2=2               MARK1194
02453  0534 00 4 00232  10001        LXA    M,4             IR4=M               MARK1195
02454  0500 00 0 02620  10001        CLA    RIB                                 MARK1196
02455  0601 00 0 02621  10001        STO    RIC                                 MARK1197
02456  0601 00 0 02622  10001        STO    RFACT                               MARK1198
02457  0601 00 4 02574  10001        STO    RIMU-2,4                            MARK1199
02460  0500 00 0 02621  10001  RLOC1 CLA    RIC                                 MARK1200
02461  0300 00 0 02620  10001        FAD    RIB                                 MARK1201
02462  0601 00 0 02621  10001        STO    RIC                                 MARK1202
02463  0131 00 0 00002  10000        ACA    2                                   MARK1203
02464  0260 00 0 02622  10001        FMP    RFACT                               MARK1204
02465  0601 00 0 02622  10001        STO    RFACT                               MARK1205
02466  0500 00 0 02576  10001        CLA    RIM             MU,MU-1,.....       MARK1206
02467  0302 00 0 02620  10001        FSB    RIB                                 MARK1207

BINARY CARD (NOT PUNCHED)
02470  0601 00 0 02576  10001        STO    RIM                                 MARK120A
02471  0131 00 0 00001  10000  RZERO ACA    1                                   MARK1209
02472  0260 00 4 02574  10001        FMP    RIMU-2,4                            MARK1210
02473  0601 00 4 02575  10001        STO    RIMU-1,4                            MARK1211
02474  0241 00 0 02622  10001        FDP    RFACT                               MARK1212
02475  0131 00 0 00000  10000        ACA                                        MARK1213
02476  6 00001 2 02501  10001        INX    RLOC2,2,1                           MARK1214
02477  0760 00 0 00002  10000        CHS                                        MARK1215
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02500  0020 00 0 02502  10001         TRA    RLOC2+1                                  MARK1216
02501  1 00001 2 02502  10001  RLOC2  TXI    RLOC2+1,2,1                              MARK1217
02502  0601 00 4 02642  10001         STO    RAJ,4          ASUBJ J=1,...,M           MARK1218
02503  2 00001 4 02460  10001         TIX    RLOC1,4,1                                MARK1219
02504  0534 00 4 00232  10001         LXA    M,4                                      MARK1220
02505  4754 00 4 00000  10000  RLOC3  PXD    0,4                                      MARK1221
02506  4734 00 2 00000  10000         PDX    0,2                                      MARK1222
02507  0534 00 1 00232  10001         LXA    M,1                                      MARK1223
02510  0500 00 2 02620  10001         CLA    RIB,2                                    MARK1224
02511  0601 00 0 02661  10001         STO    RSUMC                                    MARK1225
02512  0560 00 1 02642  10001         LDQ    RAJ,1                                    MARK1226

BINARY CARD (NOT PUNCHED)
02513  0260 00 2 02621  10001         FMP    RIB+1,2                                  MARK1227
02514  0300 00 0 02661  10001         FAD    RSUMC                                    MARK122A
02515  0601 00 0 02661  10001         STO    RSUMC                                    MARK1229
02516  1 77777 1 00401  10011         TXI    *+1,1,-1                                 MARK1230
02517  2 00001 2 02512  10001         TIX    RLOC3+5,2,1                              MARK1231
02520  0601 00 4 02661  10001         STO    RICJ,4                                   MARK1232
02521  2 00001 4 02505  10001         TIX    RLOC3,4,1                                MARK1233
02522  0534 00 1 00237  10001         LXA    (N),1          NO. OF. EQUAT.            MARK1234
02523  0534 00 2 00232  10001         LXA    M,2                                      MARK1235
02524  0534 00 4 02471  10001         LXA    RZERO,4                                  MARK1236
02525  0600 00 0 02662  10001         STZ    RSUMD                                    MARK1237
02526  0560 60 2 00273  10001  RLOC4  LDQ*   DELX,2          DIFFERENCES               MARK123B
02527  0260 00 4 02661  10001         FMP    RICJ,4                                   MARK1239
02530  0300 00 0 02662  10001         FAD    RSUMD                                    MARK1240
02531  0601 00 0 02662  10001         STO    RSUMD                                    MARK1241
02532  1 00001 4 00401  10011         TXI    *+1,4,1                                  MARK1242
02533  2 00001 2 02526  10001         TIX    RLOC4,2,1                                MARK1243
02534  0300 60 4 00273  10001         FAD*   DELX,4                                   MARK1244
02535  0131 00 0 00000  10000         XCA                                             MARK1245

BINARY CARD (NOT PUNCHED)
02536  0260 00 0 02575  10001         FMP    RIMU-1                                   MARK1246
02537  0601 00 0 02600  10001         STO    RSAVE                                    MARK1247
02540  0500 60 0 05000  10011         CLA*   Y0(2)                                    MARK124B
02541  0302 00 0 02600  10001         FSB    RSAVE                                    MARK1249
02542  0300 60 0 04400  10011         FAD*   Y0                                       MARK1250
02543  0601 60 0 03000  10011         STO*   Y                                        MARK1251
02544  4600 60 0 04000  10011         STQ*   Y(2)                                     MARK1252
02545  2 00001 1 02523  10001         TIX    RLOC4-3,1,1                              MARK1253
02546  0634 00 1 03023  10001         SXA    G7P,1                                    MARK1254
02547  0522 00 0 00250  10001         XEC    DER1                                     MARK1255
02550  0522 00 0 00216  10001         XEC    AEQS                                     MARK1256
02551  0774 00 4 00000  10000  RICH   AXT    **,4                                     MARK1257
02552  0774 00 1 00000  10000         AXT    **,1                                     MARK125B
02553  0774 00 2 00000  10000         AXT    **,2                                     MARK1259
02554  0020 00 4 00001  10000         TRA    1,4            EXIT                      MARK1260
02576  200000000021     00001  RIMU   DES    17                                       MARK1261
02576  0 00000 0 00000  10000  RIM    PZE                   MU(MU-1)(MU-2)...(MU-I)   MARK1262
02577  0 00000 0 00000  10000  RMP1   PZE                   M+1                       MARK1263
02600  0 00000 0 00000  10000  RSAVE  PZE                                            MARK1264

BINARY CARD (NOT PUNCHED)
02601  570765462703     10000         DEC    -0.3826B9955E-2        B15              MARK1265
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02602  571424166250  10000        DEC   -0.421495223E-2        B14          MARK1266
02603  571462426633  10000        DEC   -0.467749840E-2        B13          MARK1267
02604  571527142211  10000        DEC   -0.523669325E-2        B12          MARK1268
02605  571604172262  10000        DEC   -0.592405641E-2        B11          MARK1269
02606  571674557257  10000        DEC   -0.678584998E-2        B10          MARK1270
02607  572402477053  10000        DEC   -0.7892554012E-2       B9           MARK1271
02610  572462460505  10000        DEC   -0.935653659E-2        B8           MARK1272
02611  572564371164  10000        DEC   -.1136739417E-1        B7           MARK1273
02612  572723445072  10000        DEC   -0.1426917989E-1       B6           MARK1274
02613  573463146315  10000        DEC   -0.01875               B5           MARK1275
02614  573660266027  10000        DEC   -0.0263888889          B4           MARK1276
02615  574525252525  10000        DEC   -0.0416666667          B3           MARK1277
02616  575525252525  10000        DEC   -0.0833333333          B2           MARK1278
02617  600400000000  10000        DEC   -0.5                   B1           MARK1279
02620  201400000000  10000  RIB   DEC   1.0                    B0 BSUBJ VALUES (0-10)  MARK1280
02621  0 00000 0 00000  10000  RIC  PZE                                       MARK1281
02622  0 00000 0 00000  10000  RFACT PZE                        FACTORIALS   MARK1282
02642  200000000017  00001  RAJ   BES   15                     A SUB J      MARK1283

BINARY CARD (NOT PUNCHED)
02661  200000000017  00001  RICJ  BES   15                     C SUB J      MARK1284
02661  0 00000 0 00000  10000  RSUMC PZE                                     MARK1285
02662  0 00000 0 00000  10000  RSUMD PZE                                     MARK1286
02663  0634 00 1 02711  10001  UPDAT SXA   HU03,1                           MARK1287
02664  0634 00 2 02712  10001        SXA   HU04,2                           MARK1288
02665  0534 00 1 00257  10001        LXA   (N),1                 C(XR1)=(N)   MARK1289
02666  0534 00 2 00230  10001        LXA   MP1,2                 C(XR2)=M+1   MARK1290
02667  0520 00 0 00251  10001        ZET   E                                   MARK1291
02670  1 00001 2 00401  10011        TXI   *+1,2,1               BUMP XR2 IF E=1  MARK1292
02671  0634 00 2 02676  10001        SXA   HU01,2                              MARK1293
02672  0500 00 0 02714  10001        CLA   HU05                                MARK1294
02673  0400 00 0 00251  10001        ADD   E                                   MARK1295
02674  0621 00 0 02703  10001        STA   HU06                ADDRESS IS DELX + E  MARK1296
02675  0621 00 0 02706  10001        STA   HU07                                MARK1297
02676  0774 00 2 00000  10000  HU01  AXT   **,2                               MARK1298
02677  0500 60 0 03400  10011        CLA*  YDOT                               MARK1299
02700  0601 00 0 00202  10001        STO   TEMP                                MARK1300
02701  0500 00 0 00202  10001  HU02  CLA   TEMP                                MARK1301
02702  0601 00 0 00203  10001        STO   TEMP+1                              MARK1302

BINARY CARD (NOT PUNCHED)
02703  0302 60 2 00000  10000  HU06  FSB*  **,2                              MARK1303
02704  0601 00 0 00202  10001        STO   TEMP                                MARK1304
02705  0500 00 0 00203  10001        CLA   TEMP+1                              MARK1305
02706  0601 60 2 00000  10000  HU07  STO*  **,2                              MARK1306
02707  2 00001 2 02701  10001        TIX   HU02,2,1              INNER LOOP, DO M+ 1+E  MARK1307
02710  2 00001 1 02676  10001        TIX   HU01,1,1              OUTER LOOP, DO (N)  MARK1308
02711  0774 00 1 00000  10000  HU03  AXT   **,1                               MARK1309
02712  0774 00 2 00000  10000  HU04  AXT   **,2                               MARK1310
02713  0020 00 4 00001  10000        TRA   1,4                                 MARK1311
02714  0 00000 0 00273  10001  HU05  PZE   DELX                               MARK1312
02715  0020 00 0 02724  10001  DADD  TRA   DSUB+6                TSX DADD-DSUB,4  MARK1313
02716  0020 00 0 02721  10001  DSUB  TRA   DSUB+3                PZE L(A1),0,L(B1)  MARK1314
02717  0 00000 0 00000  10000        PZE                                       MARK1315
02720  0 00000 0 00000  10000        PZE                                       MARK1316
02721  0500 00 0 02716  10001        CLA   DSUB                                MARK1317
```

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02722  0601 00 0 02720  10001        STO    DSUB+2                                  MARK1318
02723  0020 00 0 00402  10011        TRA    *+2                                     MARK1319
02724  0600 00 0 02720  10001        STZ    DSUB+2                                  MARK1320
02725  0500 00 4 00001  10000        CLA    1,4                                     MARK1321

BINARY CARD (NOT PUNCHED)
02726  0601 00 0 02717  10001        STO    DSUB+1                                  MARK1322
02727  4535 00 1 02717  10001        LDQ    DSUB+1,1                                MARK1323
02730  0535 00 2 02717  10001        LAC    DSUB+1,2                                MARK1324
02731  0500 00 1 00001  10000        CLA    1,1                                     MARK1325
02732  0520 00 0 02720  10001        ZET    DSUB+2                                  MARK1326
02733  0760 00 0 00002  10000        CHS                                            MARK1327
02734  0300 00 2 00001  10000        FAD    1,2                                     MARK1328
02735  0601 00 0 00202  10001        STO    TEMP                                    MARK1329
02736  0500 00 1 00000  10000        CLA    0,1                                     MARK1330
02737  0520 00 0 02720  10001        ZET    DSUB+2                                  MARK1331
02740  0760 00 0 00002  10000        CHS                                            MARK1332
02741  0300 00 2 00000  10000        FAD    0,2                                     MARK1333
02742  0601 00 0 00203  10001        STO    TEMP+1                                  MARK1334
02743  0131 00 0 00000  10000        XCA                                            MARK1335
02744  0300 00 0 00202  10001        FAD    TEMP                                    MARK1336
02745  0300 00 0 00203  10001        FAD    TEMP+1                                  MARK1337
02746  0020 00 4 00002  10000        TRA    2,4                                     MARK1338
02747  0634 00 4 03003  10001  START SXA    GRT1,4    TEST TRANSITION FROM RK TO AM MARK1339
02750  0500 00 0 00235  10001        CLA    H                                       MARK1340

BINARY CARD (NOT PUNCHED)
02751  0300 00 0 00240  10001        FAD    T1                                      MARK1341
02752  0601 00 0 00202  10001        STO    TEMP                                    MARK1342
02753  0131 00 0 00000  10000        XCA                                            MARK1343
02754  0300 00 0 00241  10001        FAD    T2                                      MARK1344
02755  0300 00 0 00202  10001        FAD    TEMP                                    MARK1345
02756  0601 00 0 00221  10001        STO    TRG2                                    MARK1346
02757  4600 00 0 00222  10001        STQ    TRG2+1                                  MARK1347
02760  0074 00 4 02663  10001        ISX    UPDAT,4                                 MARK1348
02761  0500 00 0 00167  10001        CLA    J                                       MARK1349
02762  0400 00 0 03005  10001        ANA    START+30                                MARK1350
02763  0601 00 0 00167  10001        STO    J                                       MARK1351
02764  0520 00 0 00251  10001        ZET    E                                       MARK1352
02765  0402 00 0 03005  10001        SUB    START+30                                MARK1353
02766  0402 00 0 00230  10001        SUB    MP1                                     MARK1354
02767  4100 00 0 03003  10001        TNZ    GRT1                                    MARK1355
02770  0500 00 0 03006  10001        CLA    START+31                                MARK1356
02771  0601 00 0 00221  10001        STO    TRG2                                    MARK1357
02772  0500 00 0 00235  10001        CLA    H                                       MARK1358
02773  0601 00 0 01400  10011        STO    HC                                      MARK1359

BINARY CARD (NOT PUNCHED)
02774  0534 00 1 00237  10001        LXA    (N),1                                   MARK1360
02775  0500 60 0 03000  10011        CLA*   Y                                       MARK1361
02776  0560 60 0 04000  10011        LDQ*   Y(2)                                    MARK1362
02777  0601 60 0 04400  10011        STO*   Y0                                      MARK1363
03000  4600 60 0 05000  10011        STQ*   Y0(2)                                   MARK1364
03001  2 00001 1 40404  10011        TIX    *-4,1,1                                 MARK1365
03002  0020 00 0 00731  10001        TRA    GTU       TO AMC                        MARK1366
03003  0774 00 4 00000  10000  GRT1  AXT    **,4                                    MARK1367
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03004  0020 00 4 00001  10000          TRA   1,4                                  MARK1368
03005  000000000001     10000          DEC   1                                    MARK1369
03006  377777777777     10000          OCT   377777777777                         MARK1370
03007  0634 00 4 03021  10001  PUTB    SXA   PTB1,4                               MARK1371
03010  0534 00 1 00237  10001          LXA   (N),1      RESET DEP VAR BANK        MARK1372
03011  0500 60 0 04400  10011          CLA*  Y0          FROM SECONDARY BANK       MARK1373
03012  0601 60 0 03000  10011          STO*  Y                                    MARK1374
03013  0500 60 0 05000  10011          CLA*  Y0(2)                                MARK1375
03014  0601 60 0 04000  10011          STO*  Y(2)                                 MARK1376
03015  2 00001 1 40404  10011          TIX   *-4,1,1                              MARK1377
03016  0520 00 0 03023  10001          ZET   GZP                                  MARK1378

BINARY CARD (NOT PUNCHED)
03017  0522 00 0 00250  10001          XEC   DER1                                 MARK1379
03020  0600 00 0 03023  10001          STZ   GZP                                  MARK1380
03021  0774 00 4 00000  10000  PTB1    AXT   **,4                                 MARK1381
03022  0020 00 4 00001  10000          TRA   1,4                                  MARK1382
03023  0 00000 0 00000  10000  GZP     PZE                                        MARK1383
                               * SUBR FOR DOUBLING (MARK)                        MARK1384
                               *       TSX   X2,0                                 MARK1385
                               *       NORMAL RETURN                              MARK1386
03024  0634 00 4 03072  10001  X2,0    SXA   RX2,0,4                              MARK1387
03025  0634 00 1 03073  10001          SXA   RX2,0+1,1                            MARK1388
03026  0634 00 2 03074  10001          SXA   RX2,0+2,2                            MARK1389
03027  0500 00 0 00232  10001          CLA   M                                    MARK1390
03030  0520 00 0 00251  10001          ZET   E                                    MARK1391
03031  0500 00 0 00230  10001          CLA   MP1                                  MARK1392
03032  0361 00 0 03154  10001          ACL   RMAG                                 MARK1393
03033  0300 00 0 03154  10001          FAD   RMAG                                 MARK1394
03034  0131 00 0 00000  10000          XCA                                        MARK1395
03035  0260 00 0 01400  10011          FMP   HC                                   MARK1396
03036  0601 00 0 00202  10001          STO   TEMP                                 MARK1397
03037  0131 00 0 00000  10000          XCA                                        MARK1398
03040  0300 00 0 00241  10001          FAD   T2                                   MARK1399
03041  0601 00 0 00203  10001          STO   TEMP+1                               MARK1400

BINARY CARD (NOT PUNCHED)
03042  0500 00 0 00240  10001          CLA   T1                                   MARK1401
03043  0300 00 0 00202  10001          FAD   TEMP                                 MARK1402
03044  0601 00 0 00202  10001          STO   TEMP                                 MARK1403
03045  0131 00 0 00000  10000          XCA                                        MARK1404
03046  0300 00 0 00203  10001          FAD   TEMP+1                               MARK1405
03047  0300 00 0 00202  10001          FAD   TEMP                                 MARK1406
03050  0601 00 0 00221  10001          STO   TRG2                                 MARK1407
03051  4600 00 0 00242  10001          STO   TRG2+1                               MARK1408
03052  0500 00 0 03155  10001          CLA   RALF2                                MARK1409
03053  0621 00 0 00214  10001          STA   TRIG0                                MARK1410
03054  0500 00 0 03154  10001          CLA   RMAG                                 MARK1411
03055  0601 00 0 00252  10001          STO   HD                                   MARK1412
03056  0074 00 4 03414  10001          TSX   RSUM,4                               MARK1413
03057  0534 00 1 00237  10001          LXA   (N),1                                MARK1414
03060  0534 00 2 00230  10001  RAGS    LXA   MP1,2                                MARK1415
03061  0500 60 2 00273  10001  ROGS    CLA*  DELX,2                               MARK1416
03062  0601 60 2 00307  10001          STO*  DELY,2                               MARK1417
03063  2 00001 2 03061  10001          TIX   ROGS,2,1                             MARK1418
03064  4520 00 0 00251  10001          NZT   E                                    MARK1419
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ASSEMBLED TEXT.

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BINARY CARD (NOT PUNCHED)
     03065  0020 00 0 03070  10001          TRA RIGS                                    MARK1420
     03066  1 77777 2 00401  10011          TXI   *+1,2,-1                              MARK1421
     03067  7 00000 2 03061  10001          TXL   RGGS,2,0                              MARK1422
     03070  2 00001 1 03060  10001  RIGS    TIX   RAGS,1,1                              MARK1423
     03071  0074 00 4 03373  10001          ISX   RUPDA,4                               MARK1424
     03072  0774 00 4 00000  10000  RX2.0   AXT   **,4                                  MARK1425
     03073  0774 00 1 00000  10000          AXT   **,1                                  MARK1426
     03074  0774 00 2 00000  10000          AXT   **,2                                  MARK1427
     03075  0020 00 4 00001  10000          TRA   1,4                                   MARK1428
     03076  0634 00 4 03072  10001  RISK    SXA   RX2+0,4                               MARK1429
     03077  0634 00 1 03073  10001          SXA   RX2+0+1,1                             MARK1430
     03100  0634 00 2 03074  10001          SXA   RX2+0+2,2                             MARK1431
     03101  0600 00 0 00252  10001          STZ   HD                                    MARK1432
     03102  0560 00 0 01400  10011          LDQ   HC                                    MARK1433
     03103  0260 00 0 03156  10001          FMP   RDUBL                                 MARK1434
     03104  0601 00 0 01400  10011          STO   HC          HC=2.0HC                  MARK1435
     03105  0500 00 0 03157  10001          CLA   RBIG                                  MARK1436
     03106  0601 00 0 00221  10001          STO   TRG2                                  MARK1437
     03107  0074 00 4 03414  10001          ISX   RSUM,4                                MARK1438

BINARY CARD (NOT PUNCHED)
     03110  0534 00 1 00237  10001          LXA   (N),1                                 MARK1439
     03111  0500 00 0 03160  10001  RIN1    CLA   RAD1                                  MARK1440
     03112  0621 00 0 03124  10001          STA   RIN2                                  MARK1441
     03113  0534 00 2 00230  10001          LXA   MP1,2                                MARK1442
     03114  4634 00 2 03130  10001          SXD   RIN3,2                               MARK1443
     03115  4634 00 2 03131  10001          SXD   RIN4,2                               MARK1444
     03116  0774 00 2 00001  10000          AXT   1,2
     03117  0774 00 4 00001  10000          AXT   1,4
     03120  4520 00 0 00251  10001          NZT   E
     03121  0020 00 0 03124  10001          TRA   RIN2
     03122  0774 00 2 00000  10000          AXT   0,2
     03123  0774 00 4 00000  10000          AXT   0,4
     03124  0500 60 2 00307  10001  RIN2    CLA*  DELY,2                               MARK1448
     03125  0601 60 4 00307  10001          STO*  DELY,4                               MARK1449
     03126  1 00002 2 00401  10011          TXI   *+1,2,2                              MARK1450
     03127  1 00001 4 00401  10011          TXI   *+1,4,1                              MARK1451
     03130  7 00000 2 03124  10001  RIN3    TXL   RIN2,2,0                             MARK1452
     03131  7 00000 4 03133  10001  RIN4    TXL   ROCK,4,0                             MARK1453
     03132  0020 00 0 03151  10001          TRA   ROLL                                  MARK1454

BINARY CARD (NOT PUNCHED)
     03133  0500 00 0 03161  10001  ROCK    CLA   RAD2                                  MARK1455
     03134  0621 00 0 03124  10001          STA   RIN2                                  MARK1456
     03135  0774 00 2 00002  10000          AXT   2,2                                   MARK1457
     03136  0500 00 0 00232  10001          CLA   M                                     MARK1458
     03137  0760 00 0 00001  10000          LBT                                         MARK1459
     03140  0020 00 0 03144  10001          TRA   RIN5                                  MARK1460
     03141  0520 00 0 00251  10001          ZET   E                 M ODD               MARK1461
     03142  0774 00 2 00002  10000          AXT   2,2               ERR CONTROL(SKIP FOR NO ERR CONTROL  MARK1462
     03143  0020 00 0 03124  10001          TRA   RIN2                                  MARK1463
     03144  0774 00 2 00003  10000  RIN5    AXT   3,2               M EVEN              MARK1464
     03145  4520 00 0 00251  10001          NZT   E                                     MARK1465
     03146  0020 00 0 03124  10001          TRA   RIN2              NO ERROR CONTROL    MARK1466
     03147  0774 00 2 00001  10000          AXT   1,2                                   MARK1467
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BINARY CARD (NOT PUNCHED)
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BINARY CARD (NOT PUNCHED)
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BINARY CARD (NOT PUNCHED)

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ASSEMBLED TEXT.

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03227  0760 00 0 00001  10000        LRT                                          MARK1517
03230  0020 00 0 03324  10001        TRA     REVEN           N EVEN               MARK1518
03231  0600 00 0 03357  10001  RODD  STZ     RK0             N ODD                MARK1519
03232  0634 00 2 03320  10001        SXA     RSAV2,2                              MARK1520
03233  0634 00 4 03321  10001        SXA     RSAV3,4                              MARK1521
03234  0534 00 4 00232  10001        LXA     M,4                                  MARK1522
03235  4520 00 0 00251  10001        NZT     E                                    MARK1523
03236  1 77777 4 00401  10011        TXI     *+1,4,-1                             MARK1524
03237  0560 00 0 03356  10001        LDQ     RN                                   MARK1525
03240  0260 00 0 03353  10001        FMP     R0.5                                 MARK1526
03241  0760 00 0 00002  10000        CHS                                          MARK1527
03242  0601 00 0 03362  10001        STO     RIDEL-1                              MARK1528
03243  0300 00 0 03354  10001        FAD     RFLO1                                MARK1529
03244  0601 00 0 03361  10001        STO     RIDEL-2                              MARK1530
03245  0300 00 0 03354  10001        FAD     RFLO1                                MARK1531
03246  0601 00 0 03360  10001        STO     RIDEL-3                              MARK1532

BINARY CARD (NOT PUNCHED)
03247  0600 00 0 03363  10001        STZ     RSUM5                                MARK1533
03250  0560 00 0 03361  10001  RNTR3 LDQ     RIDEL-2                              MARK1534
03251  0260 00 0 03360  10001        FMP     RIDEL-3                              MARK1535
03252  0601 00 0 03361  10001        STO     RIDEL-2                              MARK1536
03253  0500 00 0 03360  10001        CLA     RIDEL-3                              MARK1537
03254  0300 00 0 03354  10001        FAD     RFLO1                                MARK1538
03255  0601 00 0 03360  10001        STO     RIDEL-3                              MARK1539
03256  2 00001 4 03250  10001        TIX     RNTR3,4,1                            MARK1540
03257  0500 00 0 03361  10001        CLA     RIDEL-2                              MARK1541
03260  0241 00 0 03366  10001        FDP     RFACM-1                              MARK1542
03261  4600 00 0 03367  10001        STQ     RA0                                  MARK1543
03262  0534 00 2 00230  10001        LXA     MP1,2                                MARK1544
03263  0560 00 0 03367  10001  RNTR2 LDQ     RA0                                  MARK1545
03264  0260 60 2 00273  10001        FMP*    DELX,2                               MARK1546
03265  0300 00 0 03363  10001        FAD     RSUM5                                MARK1547
03266  0601 00 0 03363  10001        STO     RSUM5                                MARK1548
03267  0500 00 0 03355  10001        CLA     RFLOM                                MARK1549
03270  0302 00 0 03357  10001        FSB     RK0                                  MARK1550
03271  0601 00 0 03365  10001        STO     RFACM-2                              MARK1551

BINARY CARD (NOT PUNCHED)
03272  0500 00 0 03362  10001        CLA     RIDEL-1                              MARK1552
03273  0300 00 0 03357  10001        FAD     RK0                                  MARK1553
03274  0601 00 0 03360  10001        STO     RIDEL-3                              MARK1554
03275  0300 00 0 03354  10001        FAD     RFLO1                                MARK1555
03276  0601 00 0 03361  10001        STO     RIDEL-2                              MARK1556
03277  0500 00 0 03357  10001        CLA     RK0                                  MARK1557
03300  0300 00 0 03354  10001        FAD     RFLO1                                MARK1558
03301  0601 00 0 03357  10001        STO     RK0                                  MARK1559
03302  0560 00 0 03357  10001        LDQ     RK0                                  MARK1560
03303  0260 00 0 03361  10001        FMP     RIDEL-2                              MARK1561
03304  0601 00 0 03370  10001        STO     RTEMP                                MARK1562
03305  0560 00 0 03365  10001        LDQ     RFACM-2                              MARK1563
03306  0260 00 0 03360  10001        FMP     RIDEL-3                              MARK1564
03307  0241 00 0 03370  10001        FDP     RTEMP                                MARK1565
03310  0260 00 0 03367  10001        FMP     RA0                                  MARK1566
03311  0760 00 0 00002  10000        CHS                                          MARK1567
03312  0601 00 0 03367  10001        STO     RA0                                  MARK1568
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03313  2 00001 2 03263  10001        TIX    RNTR2,2,1                          MARK1569
03314  4520 00 0 00251  10001        NZT    E                                  MARK1570

BINARY CARD (NOT PUNCHED)
03315  0020 00 0 03320  10001        TRA    RSAV2                              MARK1571
03316  1 77777 2 00401  10011        TXI    *+1,2,-1                           MARK1572
03317  7 00000 2 03263  10001        TXL    RNTR2,2,0                          MARK1573
03320  0774 00 2 00000  10000 RSAV2  AXT    **,2                               MARK1574
03321  0774 00 4 00000  10000 RSAV3  AXT    **,4                               MARK1575
03322  0500 00 0 03363  10001        CLA    RSUM5                              MARK1576
03323  0020 00 0 03325  10001        TRA    REVEN+1                            MARK1577
03324  0500 60 2 00273  10001 REVEN CLA*   DELX,2                             MARK157A
03325  0601 60 4 00307  10001        STO*   DELY,4                             MARK1579
03326  0500 00 0 03356  10001        CLA    RN                                 MARK1580
03327  0300 00 0 03354  10001        FAD    RFLO1                              MARK1581
03330  0601 00 0 03356  10001        STO    RN                                 MARK1582
03331  0500 00 0 03371  10001        CLA    RNPRI                              MARK1583
03332  0400 00 0 03372  10001        ADD    RFIX1                              MARK1584
03333  0601 00 0 03371  10001        STO    RNPRI                              MARK1585
03334  0760 00 0 00001  10000        LBT                                       MARK1586
03335  0020 00 0 00402  10011        TRA    *+2                                MARK1587
03336  1 77777 2 00401  10011        TXI    *+1,2,-1                           MARK1588
03337  2 00001 4 03226  10001        TIX    RNTR0,4,1                          MARK1589

BINARY CARD (NOT PUNCHED)
03340  4520 00 0 00251  10001        NZT    E                                  MARK1590
03341  0020 00 0 03344  10001        TRA    RNTR4                              MARK1591
03342  1 77777 4 00401  10011        TXI    *+1,4,-1                           MARK1592
03343  7 00000 4 03226  10001        TXL    RNTR0,4,0                          MARK1593
03344  2 00001 1 03222  10001 RNTR4  TIX    RNTR1,1,1                          MARK1594
03345  0074 00 4 03373  10001        ISX    RUPDA,4                            MARK1595
03346  0774 00 4 00000  10000  RX.5  AXT    **,4                               MARK1596
03347  0774 00 1 00000  10000        AXT    **,1                               MARK1597
03350  0774 00 2 00000  10000        AXT    **,2                               MARK1598
03351  0020 00 4 00001  10000        TRA    1,4                                MARK1599
03352  233000000000     10000 RMAGN  OCT    233000000000                       MARK1600
03353  200400000000     10000  R0.5  DEC    0.5                                MARK1601
03354  201400000000     10000 RFLO1  DEC    1.0                                MARK1602
03355  0 00000 0 00000  10000 RFLOM  PZE                 FLOAT M               MARK1603
03356  0 00000 0 00000  10000    RN  PZE                 N                     MARK1604
03357  0 00000 0 00000  10000   RKU  PZE                 K                     MARK1605
03362  200000000003     00001 RIDEL  BES    3                                  MARK1606
03363  0 00000 0 00000  10000 RSUM5  PZE                                       MARK1607
03367  200000000003     00001 RFACM  BES    3                                  MARK1608

BINARY CARD (NOT PUNCHED)
03367  0 00000 0 00000  10000   RAU  PZE                                       MARK1609
03370  0 00000 0 00000  10000 RTEMP  PZE                                       MARK1610
03371  0 00000 0 00000  10000 RNPRI  PZE                                       MARK1611
03372  0 00000 0 00001  10000 RFIX1  PZE    1                                  MARK1612
03373  0634 00 4 03410  10001 RUPDA  SXA    RUP3,4                             MARK1613
03374  0634 00 1 03411  10001        SXA    RUP3+1,1                           MARK1614
03375  0634 00 2 03412  10001        SXA    RUP3+2,2                           MARK1615
03376  0534 00 2 00230  10001        LXA    MP1,2                              MARK1616
03377  4634 00 2 03407  10001        SXD    RUP2,2                             MARK1617
03400  0774 00 2 00000  10000        AXT    0,2                                MARK1618
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03401  0534 00 1 00237  10001   RUP0  LXA    (N),1                          MARK1619
03402  0500 60 2 00307  10001   RUP1  CLA*   DELY,2                         MARK1620
03403  0601 60 0 03400  10011         STO*   YDOT                           MARK1621
03404  2 00001 1 03402  10001         TIX    RUP1,1,1                       MARK1622
03405  0074 00 4 02663  10001         ISX    UPDAT,4                        MARK1623
03406  1 00001 2 03407  10001         IXI    RUP2,2,1                       MARK1624
03407  7 00000 2 03401  10001   RUP2  TXL    RUP0,2,0                       MARK1625
03410  0774 00 4 00000  10000   RUP3  AXT    **,4                           MARK1626
03411  0774 00 1 00000  10000         AXT    **,1                           MARK1627

BINARY CARD (NOT PUNCHED)
03412  0774 00 2 00000  10000         AXT    **,2                           MARK1628
03413  0020 00 4 00001  10000         TRA    1,4                            MARK1629
                                *  SUBR TO OBTAIN DERIVATIVES FROM DIFFERENCES  MARK1630
                                *         TSX    RSUM,4                      MARK1631
                                *         NORMAL RETURN                      MARK1632
03414  0634 00 4 03451  10001   RSUM  SXA    RIRS,4                         MARK1633
03415  0634 00 1 03452  10001         SXA    RIRS+1,1                       MARK1634
03416  0634 00 2 03453  10001         SXA    RIRS+2,2                       MARK1635
03417  4520 00 0 00251  10001         NZT    E                              MARK1636
03420  0020 00 0 03455  10001         TRA    REO                            MARK1637
03421  0774 00 2 00001  10000         AXT    1,2                            MARK1638
03422  0500 00 0 00230  10001         CLA    MP1                            MARK1639
03423  0621 00 0 03433  10001         STA    RSUM1                          MARK1640
03424  0621 00 0 03435  10001         STA    RSUM2-1                        MARK1641
03425  0500 00 2 03464  10001   RECH  CLA    RADDS,2                        MARK1642
03426  0621 00 0 03437  10001         STA    RSUM3                          MARK1643
03427  0500 00 2 03463  10001         CLA    RADDS-1,2                      MARK1644
03430  0621 00 0 03440  10001         STA    RSUM4                          MARK1645
03431  0621 00 0 03441  10001         STA RSUM7                             MARK1646
03432  0534 00 1 00237  10001         LXA    (N),1          IR1=(N)         MARK1647
03433  0774 00 2 00000  10000   RSUM1 AXT    0,2                            MARK1648
03434  4634 00 2 03443  10001         SXD    RSUM6,2                        MARK1649

BINARY CARD (NOT PUNCHED)
03435  0774 00 4 00000  10000         AXT    0,4                            MARK1650
03436  0774 00 2 00001  10000   RSUM2 AXT    1,2                            MARK1651
03437  0500 60 2 00272  10001   RSUM3 CLA*   DELX-1,2                       MARK1652
03440  0302 60 2 00273  10001   RSUM4 FSB*   DELX,2                        MARK1653
03441  0601 60 2 00273  10001   RSUM7 STO*   DELX,2                        MARK1654
03442  1 00001 2 03443  10001         TXI    RSUM6,2,1                      MARK1655
03443  7 00000 2 03437  10001   RSUM6 TXL    RSUM3,2,**                     MARK1656
03444  4534 00 2 03443  10001         LXD    RSUM6,2                        MARK1657
03445  1 77777 2 00001  10011         TXI    **+1,2,-1                      MARK1658
03446  4634 00 2 03443  10001         SXD    RSUM6,2                        MARK1659
03447  2 00001 4 03436  10001         TIX    RSUM2,4,1                      MARK1660
03450  2 00001 1 03433  10001         TIX    RSUM1,1,1                      MARK1661
03451  0774 00 4 00000  10000   RIRS  AXT    **,4                           MARK1662
03452  0774 00 1 00000  10000         AXT    **,1                           MARK1663
03453  0774 00 2 00000  10000         AXT    **,2                           MARK1664
03454  0020 00 4 00001  10000         TPA    1,4                            MARK1665
03455  0500 00 0 00232  10001   REO   CLA    M                              MARK1666
03456  0621 00 0 03433  10001         STA    RSUM1                          MARK1667
03457  0621 00 0 03435  10001         STA    RSUM2-1                        MARK1668

BINARY CARD (NOT PUNCHED)
```

```
03460  0774 00 2 00000  10000          AXT    0,2                  MARK1669
03461  0020 00 0 03425  10001          TRA    RECH                 MARK1670
03462  0 00000 0 00274  10001          PZE    DELX+1               MARK1671
03463  0 00000 0 00273  10001          PZE    DELX                 MARK1672
03464  0 00000 0 00272  10001  RADDS   PZE    DELX-1               MARK1673
                00000  01111          END                         MARK1675
```

MARS 02/17/69 PAGE
CONTROL DICTIONARY

$CDICT MARS MARS0002

```
BINARY CARD (NOT PUNCHED)
          003465000000          PREFACE  START=0,LENGTH=1845,TYPE=7094,CMPLY=6
          000004000006
          442151626060  MARS    DECK
          003465000000
          442151426060  MARK    REAL     SECT. 2,LOC=0,LENGTH=0
          000000000000
          302360606060  HC      REAL     SECT. 3,LOC=165,LENGTH=0
          000000000165
          453160606060  NT      REAL     SECT. 4,LOC=166,LENGTH=0
          000000000166
          632743466060  TGLO    REAL     SECT. 5,LOC=173,LENGTH=0
          000000000173
          706060606060  Y       REAL     SECT. 6,LOC=223,LENGTH=0
          000000000223
          702446636060  YDOT    REAL     SECT. 7,LOC=224,LENGTH=0
          000000000224
          700102016060  Y121    REAL     SECT. 8,LOC=225,LENGTH=0
          000000000225
          700060606060  Y0      REAL     SECT. 9,LOC=226,LENGTH=0
          000000000226
          700001020160  Y0121   REAL     SECT. 10,LOC=227,LENGTH=0
          000000000227

BINARY CARD (NOT PUNCHED)
          256422215160  EUBAR   REAL     SECT. 11,LOC=326,LENGTH=0
          000000000326
          254322215160  ELBAR   REAL     SECT. 12,LOC=327,LENGTH=0
          000000000327
          304421676360  HMAX1   REAL     SECT. 13,LOC=330,LENGTH=0
          000000000330
          304431456360  HMINT   REAL     SECT. 14,LOC=331,LENGTH=0
          000000000331
          702343466660  YCLOW   REAL     SECT. 15,LOC=332,LENGTH=0
          000000000332
          512725515160  RGERR   REAL     SECT. 16,LOC=1671,LENGTH=0
          000000001671
```

$DKEND MARS MARS0003

NO MESSAGES FOR THIS ASSEMBLY

REFERENCES TO DEFINED SYMBOLS.

CLASS	SYMBOL	VALUE	REFERENCES
	ABTB	00414	160,637,703,731,776,1114,1267,1540
	ADAMS	01250	144,1000,1250,1257,1260,1261,1355,1360,1362
	ADDR	00334	75,551
	AFOS	00216	2,522,524,530,532,533,655,664,1043,1533,2550
	AFLAG	00220	421,444,656,1055
	AMC	00712	733,1056
	A	01676	142,1264,1266,1352,1461
	ASET	00217	420,443,647,734,1116
	BMIN	00172	423,465,503,635,726
	DADD	02715	
	DELO	00255	
	DELU	00175	157,577,615,626,633,723,746,1014,1015,2334,2430
	DELX	00273	301,1312,1405,1516,1571,1572,1623,1705,2526,2534,2714,3061,3161,3264,3324,3437,3440,3441, 3462,3463,3464
	DELY	00307	371,3062,3124,3125,3160,3325,3402
	DELZ	00323	403,1313,1515,1716
	DER1	00250	43,146,507,1170,1305,2547,3017
	DER2	00247	45,513,1401
	DSUB	02716	714,737,2316,2354,2445,2715,2716,2721,2722,2724,2726,2727,2730,2732,2737
	ELBAR	00327	0,1446
	EPC	00257	
	E	00251	53,61,74,107,112,136,374,1262,1306,1315,1350,1413,2667,2673,2764,3030,3064,3120,3141,3145, 3175,3206,3235,3314,3340,3417
	EUBAR	00326	0,1464
	FLAG	01731	220,1755
	GADN	01567	1550
	GAINT	01576	1471,1372,1605,1606,1607,1612,1614,1642
	GCOFC	01667	1332,1376,1600,1704
	GCOFP	01655	1331,1471,1577,1715
	GFRK2	01543	1363,1414,1452,1456,1457,1462,1466,1467,1474,1475
	GLP	01401	1564
	GND1	01356	1341
	GND	01342	1575
	GRT1	03003	2747,2767
	GSIGM	00256	1400,1553
	GT0	00731	3002
	GT10	01126	732,777,1012,1013,1115,1270,1541
	GT11	01101	1076,1113
	GT12	01122	1107
	GT13	01110	1124
	GT1	00734	724
	GT2	00751	141,145,1542
	GT3	01015	747,1121
	GT4	01034	1027
	GT5	01046	1025,1033
	GT6	01055	1044,1071
	GT8	01072	1060,1101
	GT9	01114	1075
	GZP	03023	1364,2546,3016,3020
	HAU1	00573	414
	HAU2	00572	415

SYMBOL REFERENCE DATA

HA03	00571	416
HA04	00434	437,445,461,467,472,474,500,504
HA05	00452	447,457
HA06	00470	451,455,456,475
HA07	00473	462
HA08	00525	515
HA09	00534	523,526
HA10	00505	435
HA11	00440	425,450
HA12	00602	417,521
HA13	00603	442,527
HA14	00604	
HA16	00542	540
HC	00165	0,71,644,648,662,1006,1134,1152,1273,1453,1454,1470,1500,1552,1631,1725,2450,2773,3035,3102, 3104,3171,3173
HD	00252	126,765,1451,1535,3055,3101,3166
HIC	00253	1062,2426,2434
HK01	01145	1174
HK02	01205	1221,1241
HK03	01154	1212,1240
HK04	01213	1242
HK05	01222	1243
HK06	01210	1230
HK07	01231	1244
HK08	01201	1131
HK09	01202	1132
HK10	01203	1133
HK11	01245	1153
HK12	01246	1135,1206,1215,1224
HK13	01247	1232
HMAXI	00330	0,1455
HMINI	00331	0,1472
HP	02437	2270,2363,2365,2413
HR01	00663	
HR02	00642	634
HR03	00711	625,632,642
HR04	00616	641
HR05	00666	661
HR07	00667	705
HR08	00705	672
HR09	00706	154,156,612
HR10	00707	671
HR11	00630	640,704
HR12	00660	605
HR13	00710	614
H	00235	70,151,554,607,643,2750,2772
HU01	02676	2071,2710
HU02	02701	2707
HU03	02711	2063
HU04	02712	2064
HU05	02714	2072
HU06	02703	2074
HU07	02706	2075
I4	00231	0,1,3,41,163,433,505,630,666,1073,1127,1735,1763,2002,2023,2271,2374
IINTRP	02442	1054,1070
J	00167	72,2761,2763

SYMBOL REFERENCE DATA

	KUTTA	01131	650,663
	L	02032	1750,1773,2017,2306,2311,2405
	LSTRT	00254	62
	LTAB	02035	2032
	L(M)	00242	17,25,31,127,131,133,135,347,543,553,556,562,564,570,762,775
	L(T1)	00243	21,35,64,1036,1050,1065,1156,1157,1162,1164,1175,1303,1510
	L(T2)	00244	23,37,65,1041,1053,1067,1161,1163,1176,1304,1511
	MARK	00000	0
	MP1	00230	344,366,400,1311,1330,1375,1402,1514,1566,1617,1701,1712,2666,2766,3031,3060,3113,3176,3207, 3224,3225,3262,3376,3422
	M	00232	26,77,342,2453,2504,2507,2523,3027,3136,3174,3205,3234,3455
	ND	00234	125,565,566,763,771,773,1534,3165
	NH	00233	124,557,560,752,756,760,1477
	NI	00166	0,1327,1340
	N	00236	32,101,106,114,115,336,364,376
	OBESE	02440	2266,2401
	OREY	01773	1747
	OBIT	02025	1777,2011
	OROY	02376	2263,2274
	OCCUR	02340	2335
	ODEN	01757	1776
	ODE	02026	2001,2024
	ODOR	02371	2302,2342
	OFI	02441	2336
	OGEE	02436	2267,2325,2331,2400,2425
	OINK	01775	1751
SET	OMAR	00062	1734,2003,2032,2033,2034,2035,2117,2201,2272,2403,2415
	OMEN	02021	2012,2014
	OMER	01761	1741,1743
	OMIT	02372	2275,2277
	OMNI	01737	1762
	ONION	02341	2337
	ONSET	02273	2373
	OOP	01770	1731,1767
	OOZE	02027	2000
	OPINE	02022	2021
	ORB	02377	2265,2340
	ORGY	02031	1736,1756,1766,2300,2301
	OUCH	01771	1732
	OUT	01765	1733,1740
	OVAL	02431	2264
	OVARY	02321	2314,2315
	OVER	02010	2022
	OZONE	01752	1774
	PHI	00246	51,537
	P	00245	14,155,453,466,473,576,613,712,735,1011
	PTB1	03021	3007
	PUTB	03007	1042,1365
	R0.5	03353	3172,3240
	RA0	03367	3261,3263,3310,3312
	RAD1	03160	3111
	RAD2	03161	3133
	RADDS	03464	3425,3427
	RAGS	03060	3070
	RAJ	02642	2502,2512
	RALF2	03155	3052

SYMBOL REFERENCE DATA

RPIG	03157	1536,3105,3167
RDUBL	03156	3103
RE0	03455	3420
REACH	02343	2313
RECH	03425	3461
REVEN	03324	3230,3323
RFACM	03367	3202,3204,3211,3212,3213,3214,3216,3260,3271,3305
RFACT	02622	2456,2464,2465,2474
RFIX1	03372	1326,1476,3332
RFLAG	02367	2346
RFLO1	03354	3203,3215,3243,3245,3254,3275,3300,3327
RFLOM	03355	3201,3267
RG1	01420	1444
RG3	01463	1447
RG4	01513	1532
RGAD	00411	357,375
RGA	01670	1335,1440
RGDI	01672	1426,1431
RGERR	01671	0,1415,1441,1443,1445,1463
RGET1	01311	1325
RGERR	00333	140
RGIN1	01000	353
RGMAX	01677	1427
RGMX	01726	1677,1700
RGUP	01337	1307,1336
RGX+2	01470	1465
RGYPC	01673	1416,1433,1436,1437,1703,1706,1707,1714,1717,1720,1723
RIB	02620	2454,2461,2467,2510,2513
RICH	02551	2442,2443,2444
RICJ	02661	2520,2527
RIC	02621	2455,2460,2462
RIDEL	03363	3242,3244,3246,3250,3251,3252,3253,3255,3257,3272,3274,3276,3303,3306
RIGS	03070	3065
RIM	02576	2451,2466,2470
RIMU	02576	2447,2457,2472,2473,2536
RIN1	03111	3151
RIN2	03124	3112,3121,3130,3134,3143,3146,3150
RIN3	03130	3114
RIN4	03131	3115
RIN5	03144	3140
RIRS	03451	3414,3415,3416
RISK	03076	3155
RKU	03357	3231,3270,3275,3277,3301,3302
RKC	00605	162,657,670
RLOC1	02460	2452,2503
RLOC2	02501	2476,2500,2501
RLOC3	02505	2517,2521
RLOC4	02526	2533,2545
RMAGN	03352	3177,3200
RMAG	03154	3032,3033,3054
RMP1	02577	
RMPR1	03371	3223,3226,3331,3333
RN	03356	3222,3237,3326,3330
RNTR0	03226	3337,3343
RNTR1	03222	3344
RNTR2	03263	3313,3317

SYMBOL REFERENCE DATA

	RMTR3	03250	3256
	RMTR4	03344	3341
	RMTR5	03211	3210,3217
	ROCK	03133	3131
	ROUD	03251	
	ROGS	03061	3063,3067
	ROLL	03151	3132
	R	02033	1753,2344,2350,2417
	RSAV2	03320	3232,3315
	RSAV3	03321	3233
	RSAVE	02600	2537,2541
	RSTOR	02332	2330,2364,2366
	RSTOT	02426	2414
	RSTRU	02415	2402
	RSTRT	00001	541,546,730,1045,1120
	RSUM1	03433	3423,3450,3456
	RSUM2	03436	3424,3447,3457
	RSUM3	03437	3426,3443
	RSUM4	03440	3430
	RSUM5	03363	3247,3265,3266,3322
	RSUM6	03443	3434,3442,3444,3446
	RSUM7	03441	3431
	RSUMC	02661	2511,2514,2515
	RSUMD	02662	2525,2530,2531
	RSUM	03414	3056,3107,3221
	RTAB	02117	2033
	RTEMP	03370	3304,3307
	RUP0	03401	3407
	RUP1	03402	3404
	RUP2	03407	3377,3406
	RUP3	03410	3373,3374,3375
	RUPDA	03373	3071,3152,3345
	RX2.0	03072	3024,3025,3026,3076,3077,3100,3153
	RX.5	03346	3162,3163,3164
	RZERO	02471	2524
LCTR	RLCTR		
QUAL	UNQS		
LCTR	//		
	SFT	01777	217
	SRCH	02263	660,1057
	STAR	01125	1072,1117,1123
	START	02747	254,2762,2765,2770
	T1	00240	30,147,575,605,617,651,715,720,740,743,1001,1035,1047,1063,1064,1177,1274,1301,1501,1506, 2004,2317,2355,2407,2421,2446,2751,3042
	T2	00241	40,622,652,1002,1040,1052,1061,1066,1200,1277,1302,1504,1507,2006,2410,2422,2754,3040
	TEMP	00202	102,104,105,111,510,511,517,531,534,536,620,624,1021,1022,1023,1030,1136,1137,1155,1213,1220, 1222,1227,1275,1300,1356,1502,1505,1544,1546,1554,1555,1621,1624,1625,1633,1636,1746,1752, 2307,2322,2324,2326,2332,2351,2360,2362,2700,2701,2702,2704,2705,2735,2742,2744,2745,2752, 2755,3036,3041,3043,3044,3046,3047
	TG02	00174	654,1004,1017,1037
	TG0	00173	0,653,740,744,1003,1020,1034,2446
	TL2	00177	2007,2412
	TL	00176	2005,2317,2411
	TMIN2	00171	430,471,476,501,623,1031,1051
	TMIN	00170	432,460,463,574,616,715,721,1024,1046
	TR2	00201	2424

SYMBOL REFERENCE DATA

TR62	00221	66,67,215,1537,2756,2757,2771,3050,3051,3106,3170
TR1GU	00214	63,422,424,431,3053
TR	00200	2355,2423
UPDAT	02663	1337,2760,3405
w	02034	1754,2305,2310,2323,2343,2347,2361,2404,2416
wTAB	02201	2034
X2.0	03024	767,1354
X.50	03162	754
Y0	00226	0,1142,1210,1235,1321,1344,1367,1407,1525,1556,2542,2777,3011
Y0(2)	00227	0,354,1205,1216,1217,1225,1226,1231,1323,1346,1370,1406,1410,1411,1530,1570,2540,3000,3013
YCLOw	00332	0,1422,1425
YDOT	00224	0,117,1151,1404,1520,2677,3403
YM2	00325	410,1324,1527
YM	00324	1322,1524
Y	00223	0,1141,1211,1236,1343,1420,1526,1560,1561,1632,1637,2543,2775,3012
Y(2)	00225	0,1234,1237,1345,1531,1557,1562,1635,1640,2544,2776,3014
(N)	00237	34,334,545,550,1140,1145,1310,1342,1366,1403,1417,1512,1551,1567,1616,2522,2665,2774,3010, 3057,3110,3220,3401,3432

$DATA

```
SYSTEM                                  00000 THRU  02717
FILE BLOCK ORIGIN                       02720
FILES       1.      UNIT05
            2.      UNIT06
            3.      UNIT16
FILE LIST ORIGIN                        02764
PRE-EXECUTION INITIALIZATION            02776
CALL ON OBJECT PROGRAM                  03023
OBJECT PROGRAM                          03030 THRU  65771

      DECK  ORIGIN      CONTROL SECTIONS (/NAME/=NON 0 LENGTH, (LOC)=DELETED, 'LOC'=MOVED, *=NOT REFERENCED)

  1. MAIN    03030      /DATA  / 03031   /HBANK1/ 03105   /CRSR  / 03546   /NEW   / 03561   /EPSTN / 03563
                        /RSN   / 03565   /GAUSS / 03566   /POWLOS/ 03575   /RECT  / 03620   /RDOTS / 17405
                        /CONST / 17407   /GRAPH1/ 17416   /GRAPH0/ 17426    ..... 21470 *
  2. INPU    21504      /DATA  /(03031)  /HBANK1/(03105)  /CRSR  /(03546)  /CONST /(17407)  /NEW   /(03561)
                        /RECT  /(03620)  /RSN   /(03565)  /RBLK1 / 21505   /GRAPH0/(17426)  /GRAPH1/(17416)
                        /GRAPH2/ 21512    INPUT  23676
  3. OUTPU   23712      /EPSTN /(03563)  /DATA  /(03031)  /HBANK1/(03105)  /CRSR  /(03546)  /GAUSS /(03566)
                        /POWLOS/(03575)  /GRAPH2/(21512)  /RECT  /(03620)  /RDOTS /(17405)   OUTPUT  26606
  4. SC      26625      /GRAPH0/(17426)  /GRAPH1/(17416)  /CONST /(17407)
  5. SCA     26625       PRAM    26652
  6. CALCU   26720      /GRAPH0/(17426)  /GRAPH1/(17416)   CALC04  30656    CALC05  30734    CALC01  31012
                         CALC02  31015    CALC03  31020
  7. DENS    31023      /RECT  /(03620)  /GRAPH0/(17426)  /DATA  /(03031)  /HBANK1/(03105)  /RBLK1 /(21505)
                         DENSE   32206
  8. FIEL    32222      /EXFLD / 32223   /DATA  /(03031)  /HBANK1/(03105)  /GAUSS /(03566)  /CRSR  /(03546)
                         FIELD   32476
  9. POWER   32504      /DATA  /(03031)  /HBANK1/(03105)  /POWLOS/(03575)  /CRSR  /(03546)  /GAUSS /(03566)
                        /EXFLD /(32223)   POWERL  34735
 10. FORC    34747      /DATA  /(03031)  /HBANK1/(03105)   FORCE   34774
 11. COL     35006       COLL    35253
 12. CST     35304       CSINT   36271
 13. POLA    36330      /DATA  /(03031)  /HBANK1/(03105)  /CRSR  /(03546)   POLAR   36541
 14. IO      36553       IOR     36661
 15. MIN     36677       MINV    37434
 16. SMK2    37535       SMARK   37535    SMARK  (37535)   TRA14   37740    TRA24   37745    ON      37752
                         ON     (37752)   OFF     37773    OFF    (37773)
 17. MARS    40147       MARK    40147    HC      40334 *  NT      40335 *  TGLO    40342 *  Y       40372 *
                         YOUT    40373 *  Y121    40374 *  Y0      40375 *  Y0121   40376 *  EUBAR   40475
                         ELBAR   40476    HMAXI   40477    HMINT   40500    YCLOW   40501    RGERR   42040
 18. .LXCOM  43634       .LXSTR  43634 *  .LXSIP  43637    .LXOUT  43705    .LXERR  43714    .LXCAL  43717 *
                         .LXRIN  43717    IBEXIT  43717 *  .DBCLS  44101 *  .LXARG  44251    .IO     44274 *
                         .CLSE   44302    .LFBL   44303 *  .LUNB   44304    .DFOUT  44305
 19. .IODEF  44311       .DEFIN  44311    .ATTAC  44315 *  .CLOSF  44317    .OPEN   44321    .READ   44323
                         .WRITE  44325    .BSR    44335    .READR  44345 *  .RELES  44347 *  .LAREA  44360 *
                         .LFBLK  44376    .LISX   44401 *  .RLHLD  44411 *  .AREA1  44414    .LUNBL  44422 *
                         .ENTRY  44426    .GOA    44463    .GO     44467    .DERR   44503    .NOPXI  44504
                         .COMAJ  44506    .FX34   44530
 20. .IOCSF  44535
 21. .LXSL   47037       .LXSEL  47037    .LXSL1  47040    .LXTST  47043 *  .LXOVL  47103 *  .LXMOD  47145 *
                         .LXIND  47171 *  .LXDIS  47174 *  .LXFLG  47175 *  .LTCH   47176
 22. .FPTRP  47204       .FFPT.  47204 *  .FPOUT  47341    .FPARG  47347    /.COUNT/ 47351 *  OVFLOW  47415 *
 23. .ERAS.  47424       E.1     47424    E.2     47425    E.3     47426    E.4     47427
```

* MEMORY MAP *

24.	.XCC.	47430	CC.1	47430	CC.2	47431	CC.3	47432	CC.4	47433			
25.	XIT	47434	EXIT	47434	.EXIT.	47434							
26.	FXEM	47435	FMTLOC	47435 *	EOFCL.	47436	.RDLD.	47437	.FXEM.	47440	.FXOUT	47776	
			.FAARG	50004	/.OPTW./	50060							
27.	FOUT	50071	.FOUT.	50071									
28.	FCNV	50465	.FCON.	50465	.FCNV.	50510	.ENDFS	50522	.CNVSW	50524	.FDX1	50530	
			.FDX2	50531	.DBC	50533	.DBC10	50671	.DBC20	50717	.DDSW	50735	
			.DUF1X	50741	.FIXSW	50742	.DDBC	51007	.DDRS1	51247	.DDRS2	51251	
			.D1	51254	.D2	51256	.FERR2	51343 *	.ANPT	51377	.ONPT	51414	
			.LNTP	51477	.AOUT	51546	.DELT	51564	.FLT	51720	.DEXPN	52010	
			.FXD	52011	.HOUT	52146	.INTG	52216	.LOUT	52300	.OOUT	52317	
			.XCF	52350	.TEST	53075	.KOUNT	53076	.LIST	53101	.DONE	53112	
			.OUTBF	53156	.BUF	53205	.OSTO	53206	.WIDTH	53207	.GAIN	53210	
			.GAIN1	53211	.FBDBF	53221	.DUDFL	53245	.DDFLG	53246	.MOD	53247	
			.PEX	53250	.FEXP	53251	.DIG	53252					
29.	FIOS	53267	.FIOS.	53267	.FSEL.	53437	.FILR.	53443	.FRTB.	53452 *	.FRTD.	53457	
			.FILL.	53462	.FCLS	53464 *	.FOPN	53470 *	REOF	53474 *	.TOUT.	53642	
			.REEU	53650 *	.BIN	53651 *	.FCT	53652 *	.FCKSZ	53654 *			
30.	FIOH	53764	.FIOH.	53764	.FFIL.	54547	.FRTN.	54574					
31.	FWRD	54772	.FWRD.	54772									
32.	FRDD	55016	.FRDD.	55016									
33.	FRDU	55044	.FRDU.	55044									
34.	UN05	55105	.UN05.	55105									
35.	UN06	55106	.UN06.	55106	.BUFSZ	55107							
36.	FIOU	55112	.FIOU.	55112	.CTUIO	55610	.NMLST	55633	.NAME.	56737	.TNTAP	56740	
37.	FLOG	57363	ALOG10	57363	ALOG	57364							
38.	FXPF	57567	EXP	57567									
39.	FSCN	57710	COS	57710	SIN	57711							
40.	FSQR	60104	SQRT	60104									
41.	FATN	60157	ATAN2	60157	ATAN	60160							
42.	FXP1	60411	.XP1.	60411									
43.	FXP2	60525	.XP2.	60525									
44.	FXP3	60643	.XP3.	60643									
45.	FSLDI	60770	.FSLI.	61006	.FSDI.	61014 *							
46.	FSLI	61025	.SLI.	61025	.SLI1.	61032	.SDI.	61040	.SDI1.	61046			
47.	FSLDO	61061	.FSLO.	61077	.FSDO.	61105 *							
48.	FSLO	61116	.SLO.	61116	.SLO2.	61124	.SDO.	61131	.SDO2.	61140			
49.	FCAB	61152	CABS	61152									
50.	FCAS	61212	.CFMP.	61212	.CFDP.	61213							
51.	FCSQ	61337	CSQRT	61337									
52.	FTNC	61413	COTAN	61413 *	TAN	61414	CRIT	61557 *					
53.	FASC	61636	ARCOS	61636	ARSIN	61637 *							
54.	PLT770	61767	OFFSET	61770 *	WHERE	62006	FACTOR	62023 *	PLOTS	62030	PLOT	62113	
55.	SYMBLZ	63304	SYMBOL	63304									
56.	AXISZ	64110	AXIS	64674									
57.	LINEZ	64746	LINE	65300									
58.	NUMBRZ	65361	NUMBER	65732									

I/O BUFFERS 65772 THRU 77077

UNUSED CORE 77100 THRU 77211

* MEMORY MAP *

SYSTEM 00000 THRU 02717
FILE BLOCK ORIGIN 02720
FILES 1. UNIT05
2. UNIT06
3. UNIT16
FILE LIST ORIGIN 02764
PRE-EXECUTION INITIALIZATION 02772
CALL ON OBJECT PROGRAM 03025
OBJECT PROGRAM 03030 THRU 65754

DECK ORIGIN CONTROL SECTIONS (/NAME/=NON 0 LENGTH, (LOC)=DELETED, 'LOC'=MOVED, *=NOT REFERENCED)

1. MAIN	03030	/DATA / 03031	/HBANK1/ 03105	/CRSR / 03546	/NEW / 03561	/EPSTN / 03563							
		/RSN / 03565	/GAUSS / 03566	/POWLOS/ 03575	/RECT / 03620	/RDOTS / 17405							
		/CONST / 17407	/GRAPH1/ 17416	/GRAPH0/ 17426	..... 21470 *								
2. INPU	21504	/DATA /(03031)	/HBANK1/(03105)	/CRSR /(03546)	/CONST /(17407)	/NEW /(03561)							
		/RECT /(03620)	/RSN /(03565)	/RBLK1 / 21505	/GRAPH0/(17426)	/GRAPH1/(17416)							
		/GRAPH2/ 21512	INPUT 23676										
3. OUTPU	23712	/EPSTN /(03563)	/DATA /(03031)	/HBANK1/(03105)	/CRSR /(03546)	/GAUSS /(03566)							
		/POWLOS/(03575)	/GRAPH2/(21512)	/RECT /(03620)	/RDOTS /(17405)	OUTPUT 26606							
4. SC	26625	/GRAPH0/(17426)	/GRAPH1/(17416)	/CONST /(17407)									
5. SCA	26625	PRAM 26652											
6. CALCU	26720	/GRAPH0/(17426)	/GRAPH1/(17416)	CALC04 30656	CALC05 30734	CALC01 31012							
		CALC02 31015	CALC03 31020										
7. DENS	31023	/RECT /(03620)	/DATA /(03031)	/HBANK1/(03105)	/RBLK1 /(21505)	DENSE 32171							
8. FIEL	32205	/EXFLD / 32206	/DATA /(03031)	/HBANK1/(03105)	/GAUSS /(03566)	/CRSR /(03546)							
		FIELD 32455											
9. POWER	32467	/DATA /(03031)	/HBANK1/(03105)	/POWLOS/(03575)	/CRSR /(03546)	/GAUSS /(03566)							
		/EXFLD /(32206)	POWERL 34720										
10. FORC	34732	/DATA /(03031)	/HBANK1/(03105)	FORCE 34757									
11. COL	34771	COLL 35236											
12. CST	35267	CSINT 36254											
13. POLA	36315	/DATA /(03031)	/HBANK1/(03105)	/CRSR /(03546)	POLAR 36524								
14. TO	36536	TOK 36644											
15. MIN	36662	MINV 37417											
16. SMK2	37520	SMARK 37520	SMARK (37520)	TRA14 37723	TRA24 37730	ON 37735							
		ON (37735)	OFF 37756	OFF (37756)									
17. MARS	40132	MARK 40132	HC 40317 *	NT 40320 *	TGLO 40325 *	Y 40355 *							
		YOUT 40356 *	Y1&1 40357 *	Y0 40360 *	Y0121 40361 *	EUBAR 40460							
		ELBAR 40461	HMAXT 40462	HMINT 40463	YCLOW 40464	RGEPR 42023							
18. .LXCOM	43617	.LXSTR 43617 *	.LXSTP 43622	.LXOUT 43670	.LXERR 43677	.LXCAL 43702 *							
		.LXRTN 43702	IRETIT 43702 *	.DBCLS 44064 *	.LXARG 44234	.LO 44257 *							
		.CLSE 44265	.LFBL 44266 *	.LUNB 44267	.DFOUT 44270								
19. .IODEF	44274	.DEFIN 44274	.AITAC 44300 *	.CLOSE 44302	.OPEN 44304	.READ 44306							
		.WRITE 44310	.RBR 44320	.PEADR 44330 *	.RELES 44332 *	.LAREA 44343 *							
		.LFBLK 44361	.LTSX 44364 *	.PLHLD 44374 *	.AREA1 44377	.LUNBI 44405 *							
		.ENTRY 44411	.GOA 44446	.GO 44452	.DERR 44466	.NOPXI 44467							
		.COMXI 44471	.FX34 44513										
20. .IOCSF	44520												
21. .LXSL	47022	.LXSEL 47022	.LXSL1 47023	.LXTST 47026 *	.LXOVI 47066 *	.LXMOD 47130 *							
		.LXIND 47154 *	.LXDIS 47157 *	.LXFLG 47160 *	.LTCH 47161								
22. .FPTRP	47167	.FPPI. 47167 *	.FPOUT 47324	.FPARG 47332	/.COUNT/ 47334 *	OVFLOW 47400 *							
23. .ERAS.	47407	E.1 47407	E.2 47410	E.3 47411	E.4 47412								
24. .XCC.	47413	CC.1 47413	CC.2 47414	CC.3 47415	CC.4 47416								

25. XIT	47417	EXIT	47417	.EXIT.	47417						
26. FXEM	47420	FMTLOC	47420 *	EOFCL.	47421	.RDLD.	47422	.FXEM.	47423	.FXOUT	47761
		.EXARG	47767	/.OPTN./	50043						
27. FOUT	50054	.FOUT.	50054								
28. FCNV	50450	.FCON.	50450	.FCNV.	50473	.ENDFS	50505	.CNVSW	50507	.FDX1	50513
		.FDX2	50514	.DBC	50516	.DBC10	50654	.DBC20	50702	.DDSW	50720
		.DDFIX	50724	.FIXSW	50725	.DDBC	50772	.DDRS1	51232	.DDRS2	51234
		.D1	51237	.D2	51241	.FERR2	51326 *	.ANPT	51362	.ONPT	51377
		.LNTP	51462	.AOUT	51531	.DFLT	51547	.FLT	51703	.DEXPN	51773
		.FXD	51774	.HOUT	52131	.INTG	52201	.LOUT	52263	.OOUT	52302
		.XCF	52333	.TEST	53056	.KOUNT	53061	.LIST	53064	.DONE	53075
		.OUTBF	53141	.BUF	53170	.OSTO	53171	.WIDTH	53172	.GAIN	53173
		.GAIN1	53174	.FBDBF	53204	.DDDFL	53230	.DDFLG	53231	.MOD	53232
		.PEX	53233	.FEXP	53234	.DIG	53235				
29. FIOS	53252	.FIOS.	53252	.FSEL.	53422	.FILR.	53426	.FRTB.	53435 *	.FRTD.	53442
		.FILL.	53445	.FCLS	53447 *	.FOPN	53453 *	REOF	53457 *	.TOUT.	53625
		.REED	53633 *	.BIN	53634 *	.FCT	53635 *	.FCKSZ	53637 *		
30. FIOH	53747	.FIOH.	53747	.FFIL.	54532	.FRTN.	54557				
31. FWRD	54755	.FWRD.	54755								
32. FRDD	55001	.FRDD.	55001								
33. FRDU	55027	.FRDU.	55027								
34. UN05	55070	.UN05.	55070								
35. UN06	55071	.UN06.	55071	.BUFSZ	55072						
36. FIOU	55075	.FIOU.	55075	.CTIO10	55573	.NMLST	55616	.NAME.	56722	.TNTAP	56723
37. FLOG	57346	ALOG10	57346	ALOG	57347						
38. FXPF	57552	EXP	57552								
39. FSCN	57673	COS	57673	SIN	57674						
40. FSQR	60067	SQRT	60067								
41. FATN	60142	ATAN2	60142	ATAN	60143						
42. FXP1	60374	.XP1.	60374								
43. FXP2	60510	.XP2.	60510								
44. FXP3	60626	.XP3.	60626								
45. FSLDI	60753	.FSLI.	60771	.FSDI.	60777 *						
46. FSLI	61010	.SLI.	61010	.SLI1.	61015	.SDI.	61023	.SDI1.	61031		
47. FSLDO	61044	.FSLO.	61062	.FSDO.	61070 *						
48. FSLO	61101	.SLO.	61101	.SLO2.	61107	.SDO.	61114	.SDO2.	61123		
49. FCAB	61135	CABS	61135								
50. FCAS	61175	.CFMP.	61175	.CFDP.	61176						
51. FCSQ	61322	CSQRT	61322								
52. FTNC	61376	COTAN	61376 *	TAN	61377	CRIT	61542 *				
53. FASC	61621	ARCOS	61621	ARSIN	61622 *						
54. PLT770	61752	OFFSET	61753 *	WHERE	61771	FACTOR	62006 *	PLOTS	62013	PLOT	62076
55. SYMBLZ	63267	SYMBOL	63267								
56. AXISZ	64073	AXIS	64657								
57. LINEZ	64731	LINE	65263								
58. NUMBRZ	65344	NUMBER	65715								

I/O BUFFERS 65755 THRU 77062

UNUSED CORE 77065 THRU 77211

SAMPLE CASE GENERATED FOR DOCUMENTATION

INITIAL RAY POSITION		INITIAL RAY DIRECTION	
RO	9295.40	AO	65.99
THETAO	77.44	BO	0.00
PHIO	90.00	DELAO	0.00

RAY CHARACTERISTICS		FIELD LINE	
FREQ	1.00	LAMBDA	53.94
MODE	-1	L-VALUE	1.53

STOP CONDITIONS	MAX	MIN	INTERVALS	
RADIUS	11000.0	6378.0	PRINT	200.0
THETA	180.0	0.0	PLOT	100.0
PHI	360.0	0.0	STEP	20.0

PROGRAM OPTIONS		OTHER INITIAL VALUES	
NPOWER	0	SCALE SIZE	0.707
NPLOT	1	PKFRAC	0.050
NOVER	0	HPRIME	1.176
NAUTO	0	PKDELN	60.549
JTEST	2		

UNDRFLOW AT 20504 IN MQ

UNDRFLOW AT 20520 IN AC AND MQ.

UNDRFLOW AT 20504 IN MQ

UNDRFLOW AT 20520 IN AC AND MQ.

UNDRFLOW AT 20504 IN MQ

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP / Y**2 / NU	POWER LOSS / EPSTEIN CD / GROUP DELAY
2.0000000E 01	9.3041084E 03	7.7566658E 01	8.9999987E 01	9.9999999E-01	0.0000000E-39	0.0000000E-39
2.4031575E 01	3.7083140E-01	8.4940216E-01	-0.0000000E-39	8.5899997E-01	8.5899995E-01	3.2884926E-13
2.1583306E 01	1.0000023E 00	-9.0000000E 01	2.1791243E-05	1.2074153E 03	8.6929314E-06	8.0105249E-02
2.0000000E 02	9.3790591E 03	7.8663387E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3919784E 02	3.5227335E-01	8.6049035E-01	0.0000000E-39	8.6454017E-01	8.6454015E-01	1.8393076E-13
2.1547645E 02	1.0000086E 00	-9.0000000E 01	1.2532970E-05	1.1775214E 03	5.1706413E-06	7.9732613E-01
4.0000000E 02	9.4549106E 03	7.9885571E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.7618443E 02	3.1247831E-01	8.7869874E-01	0.0000000E-39	8.6975418E-01	8.6975416E-01	1.0242290E-13
4.3024053E 02	1.0000001E 00	-9.0000000E 01	7.7818205E-06	1.1486853E 03	3.0565067E-06	1.5872814E 00
6.0000000E 02	9.5233201E 03	8.1110764E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
7.1136256E 02	2.7305632E-01	8.9420238E-01	0.0000000E-39	8.7415765E-01	8.7415764E-01	6.0527487E-14
6.4441360E 02	1.0000071E 00	-9.0000000E 01	1.6612134E-05	1.1237326E 03	1.9024320E-06	2.3712085E 00
8.0000000E 02	9.5831912E 03	8.2340916E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
9.4506111E 02	2.4719298E-01	9.0372165E-01	0.0000000E-39	8.7781720E-01	8.7781718E-01	3.8245256E-14
8.5809700E 02	1.0000027E 00	-9.0000000E 01	2.1914030E-05	1.1025245E 03	1.2563415E-06	3.1502037E 00
1.0000000E 03	9.6338651E 03	8.3576100E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.1775500E 03	2.1059714E-01	9.1457866E-01	0.0000000E-39	8.8080530E-01	8.8080528E-01	2.5948592E-14
1.0713754E 03	1.0000034E 00	-9.0000000E 01	9.8592200E-06	1.0848494E 03	8.8431544E-07	3.9251668E 00
1.2000000E 03	9.6763511E 03	8.4814052E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.4090642E 03	1.6285635E-01	9.2559346E-01	0.0000000E-39	8.8324545E-01	8.8324544E-01	1.8751383E-14
1.2843241E 03	1.0000041E 00	-9.0000000E 01	1.0791444E-05	1.0700884E 03	6.5878622E-07	4.6968806E 00
1.4000000E 03	9.7104039E 03	8.6054828E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.6398141E 03	1.2611563E-01	9.3235042E-01	0.0000000E-39	8.8518248E-01	8.8518245E-01	1.4453184E-14
1.4970117E 03	1.0000010E 00	-9.0000000E 01	2.3180092E-05	1.0580794E 03	5.2030317E-07	5.4660469E 00
1.6000000E 03	9.7346377E 03	8.7298759E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.8699834E 03	8.5122531E-02	9.3677850E-01	0.0000000E-39	8.8660226E-01	8.8660225E-01	1.2002435E-14
1.7094989E 03	1.0000070E 00	-9.0000000E 01	1.5447359E-05	1.0490262E 03	4.3987898E-07	6.2332779E 00
1.8000000E 03	9.7496772E 03	8.8544160E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.0997386E 03	4.7070662E-02	9.4092793E-01	0.0000000E-39	8.8756100E-01	8.8756102E-01	1.0686431E-14
1.9218413E 03	1.0000001E 00	-9.0000000E 01	9.0264119E-06	1.0426152E 03	3.9635041E-07	6.9991287E 00
2.0000000E 03	9.7562792E 03	8.9790206E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3292425E 03	5.3855051E-04	9.4239670E-01	0.0000000E-39	8.8811183E-01	8.8811182E-01	1.0141845E-14
2.1340939E 03	1.0000062E 00	-9.0000000E 01	1.7753554E-05	1.0385536E 03	3.7861936E-07	7.7641417E 00
2.0026441E 03	9.7562800E 03	8.9806684E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3322757E 03	-9.9151940E-05	9.4239864E-01	0.0000000E-39	8.8811521E-01	8.8811520E-01	1.0141433E-14
2.1368996E 03	1.0000064E 00	-9.0000000E 01	1.7272333E-05	1.0385236E 03	3.7861733E-07	7.7742522E 00

RDOT = -0.256018E-10

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP / Y**2 / NU	POWER LOSS / EPSTEIN CO / GROUP DELAY
2.2000000E 03	9.7533718E 03	9.1036575E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.5587009E 03	-3.0006336E-02	9.4176053E-01	0.0000000E-39	8.8781328E-01	8.8781327E-01	1.0383982E-14
2.3463297E 03	1.0000025E 00	-9.0000000E 01	2.1992870E-05	1.0408437E 03	3.8631913E-07	8.5290028E 00
2.4000000E 03	9.7405720E 03	9.2282115E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.7883552E 03	-7.0891676E-02	9.3911811E-01	0.0000000E-39	8.8696846E-01	8.8696845E-01	1.1466033E-14
2.5586364E 03	1.0000024E 00	-9.0000000E 01	1.0138950E-05	1.0466211E 03	4.2215269E-07	9.2945173E 00
2.6000000E 03	9.7192051E 03	9.3526370E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.0183646E 03	-1.2064937E-01	9.3334941E-01	0.0000000E-39	8.8569740E-01	8.8569738E-01	1.3509765E-14
2.7710679E 03	1.0000049E 00	-9.0000000E 01	1.1550780E-05	1.0548366E 03	4.8951262E-07	1.0061215E 01
2.8000000E 03	9.6891510E 03	9.4768933E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.2488991E 03	-1.5656663E-01	9.2706798E-01	0.0000000E-39	8.8396815E-01	8.8396814E-01	1.7003786E-14
2.9836814E 03	1.0000005E 00	-9.0000000E 01	2.3382330E-05	1.0656361E 03	6.0283022E-07	1.0829664E 01
3.0000000E 03	9.6493534E 03	9.6007865E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.4801365E 03	-1.8710618E-01	9.2015684E-01	0.0000000E-39	8.8169734E-01	8.8169732E-01	2.3049394E-14
3.1965358E 03	1.0000068E 00	-9.0000000E 01	1.4377438E-05	1.0794885E 03	7.9426515E-07	1.1600455E 01
3.2000000E 03	9.6008059E 03	9.7243106E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.7122717E 03	-2.3219256E-01	9.0827195E-01	0.0000000E-39	8.7887131E-01	8.7887131E-01	3.3414795E-14
3.4096949E 03	1.0000003E 00	-9.0000000E 01	8.4454776E-06	1.0963403E 03	1.1119204E-06	1.2374239E 01
3.4000000E 03	9.5443655E 03	9.8475507E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.9455325E 03	-2.7338235E-01	8.9483298E-01	0.0000000E-39	8.7546400E-01	8.7546396E-01	5.1496354E-14
3.6232323E 03	1.0000072E 00	-9.0000000E 01	1.6913921E-05	1.1162171E 03	1.6441106E-06	1.3151775E 01
3.6000000E 03	9.4792747E 03	9.9703398E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.1801808E 03	-2.9854333E-01	8.8443135E-01	0.0000000E-39	8.7134694E-01	8.7134693E-01	8.4905355E-14
3.8372307E 03	1.0000025E 00	-9.0000000E 01	2.1458650E-05	1.1397123E 03	2.5813040E-06	1.3933936E 01
3.8000000E 03	9.4054098E 03	1.0092554E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.4165199E 03	-3.3120860E-01	8.6988204E-01	0.0000000E-39	8.6639392E-01	8.6639389E-01	1.5002362E-13
4.0517841E 03	1.0000035E 00	-9.0000000E 01	9.2783632E-06	1.1673512E 03	4.3070709E-06	1.4721733E 01
4.0000000E 03	9.3240365E 03	1.0214426E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.6549209E 03	-3.7075416E-01	8.5032947E-01	0.0000000E-39	8.6051887E-01	8.6051886E-01	2.8165519E-13
4.2670051E 03	1.0000038E 00	-9.0000000E 01	8.7714449E-06	1.1993057E 03	7.5706798E-06	1.5516403E 01
4.2000000E 03	9.2053370E 03	1.0336028E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.8958493E 03	-4.0079329E-01	8.3240772E-01	0.0000000E-39	8.5353786E-01	8.5353786E-01	5.6172143E-13
4.4830317E 03	1.0000049E 00	-9.0000000E 01	1.9825234E-05	1.2362420E 03	1.4000840E-05	1.6319498E 01
4.4000000E 03	9.1386191E 03	1.0457172E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.1398913E 03	-4.1943090E-01	8.1805645E-01	0.0000000E-39	8.4513867E-01	8.4513863E-01	1.1982238E-12
4.7000334E 03	1.0000060E 00	-9.0000000E 01	1.8242112E-05	1.2794121E 03	2.7374596E-05	1.7132971E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CO
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
4.6000000E 03	6.0341672E 03	1.0577948E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.3878067E 03	-4.4653989E-01	7.9722627E-01	0.0000000E-39	8.3496762E-01	8.3496760E-01	2.7334357E-12
4.9182239E 03	1.0000029E 00	-9.0000000E 01	7.8593554E-06	1.3300455E 03	5.6476075E-05	1.7959356E 01
4.8000000E 03	6.9627870E 03	1.0696736E 02	8.9999987E 01	9.9999998E-01	-0.0000000E-39	0.0000000E-39
5.6406244E 03	-4.7624905E-01	7.7186092E-01	0.0000000E-39	8.2258245E-01	8.2258243E-01	6.6443718E-12
5.1378847E 03	1.0000040E 00	-9.0000000E 01	7.7193462E-06	1.3895433E 03	1.2225591E-04	1.8802081E 01
5.0000000E 03	6.8044321E 03	1.0819754E 02	8.9999987E 01	9.9999996E-01	-0.0000000E-39	0.0000000E-39
5.8997850E 03	-4.9878174E-01	7.4731603E-01	0.0000000E-39	8.0726448E-01	8.0726446E-01	1.7274905E-11
5.3593978E 03	1.0000106E 00	-9.0000000E 01	1.6302467E-05	1.4603148E 03	2.7778626E-04	1.9665950E 01
5.2000000E 03	6.6784774E 03	1.0941081E 02	8.9999987E 01	9.9999990E-01	-0.0000000E-39	0.0000000E-39
6.1673809E 03	-5.0963041E-01	7.2673517E-01	0.0000000E-39	7.8786719E-01	7.8786717E-01	4.8510695E-11
5.5832983E 03	1.0000013E 00	-9.0000000E 01	2.2563366E-05	1.5461703E 03	6.6541135E-04	2.0557936E 01
5.4000000E 03	6.5444343E 03	1.1063023E 02	8.9999987E 01	9.9999971E-01	-0.0000000E-39	0.0000000E-39
6.4466136E 03	-5.2055878E-01	7.0118118E-01	0.0000000E-39	7.6263650E-01	7.6263649E-01	1.4875621E-10
5.8103724E 03	1.0000116E 00	-9.0000000E 01	1.1983707E-05	1.6526221E 03	1.6861419E-03	2.1488712E 01
5.6000000E 03	6.4020784E 03	1.1186423E 02	8.9999987E 01	9.9999910E-01	-0.0000000E-39	0.0000000E-39
6.7427452E 03	-5.3294584E-01	6.6880109E-01	0.0000000E-39	7.2876033E-01	7.2876032E-01	5.0449349E-10
6.0418512E 03	1.0000011E 00	-9.0000000E 01	9.6960802E-06	1.7877511E 03	4.5268798E-03	2.2475817E 01
5.8000000E 03	6.2302322E 03	1.1312484E 02	8.9999987E 01	9.9999690E-01	-0.0000000E-39	0.0000000E-39
7.0652869E 03	-5.3844530E-01	6.2550457E-01	0.0000000E-39	6.8117932E-01	6.8117930E-01	1.9454402E-09
6.2796304E 03	1.0000045E 00	-9.0000000E 01	1.2596680E-05	1.9652429E 03	1.2982543E-02	2.3550956E 01
6.0000000E 03	6.0659960E 03	1.1443288E 02	8.9999987E 01	9.9998741E-01	-0.0000000E-39	0.0000000E-39
7.4340717E 03	-5.2961257E-01	5.7372595E-01	0.0000000E-39	6.0965095E-01	6.0965094E-01	9.0554304E-09
6.5283505E 03	1.0000205E 00	-9.0000000E 01	2.0025418E-05	2.2105284E 03	4.0581925E-02	2.4780239E 01
6.2000000E 03	7.9021177E 03	1.1583795E 02	8.9999987E 01	9.9993350E-01	-0.0000000E-39	0.0000000E-39
7.9026678E 03	-4.9064412E-01	4.9799377E-01	0.0000000E-39	4.8872946E-01	4.8872944E-01	5.9473729E-08
6.7971518E 03	1.0000276E 00	-9.0000000E 01	4.0952171E-05	2.5808514E 03	1.4541343E-01	2.6342226E 01
6.4000000E 03	7.6052626E 03	1.1756780E 02	8.9999987E 01	9.9923291E-01	-0.0000000E-39	0.0000000E-39
8.7837786E 03	-3.2804337E-01	3.0693748E-01	0.0000000E-39	2.0182307E-01	2.0182307E-01	1.4124313E-06
7.1308394E 03	1.0000614E 00	-9.0000000E 01	2.7707806E-04	3.3209406E 03	7.5289610E-01	2.9279262E 01
6.4399581E 03	7.5721345E 03	1.1823083E 02	8.9999987E 01	9.9613941E-01	-0.0000000E-39	0.0000000E-39
9.8500502E 03	-3.3383497E-05	-9.5281497E-04	0.0000000E-39	9.0897083E-07	9.0897082E-07	1.1258891E 00
7.2590909E 03	1.4988323E 00	9.0000006E 01	5.9509908E 04	3.7784665E 03	1.4373578E 00	3.2833500E 01

RDOT = 0.3007026E 03

6.6000000E 03	7.8186420E 03	1.1645662E 02	8.9999987E 01	9.9241554E-01	-0.0000000E-39	0.0000000E-39
1.1552453E 04	6.5268922E-01	-4.5387141E-01	0.0000000E-39	4.1092679E-01	4.1092678E-01	1.5466445E-07
7.6019791E 03	1.0000004E 00	9.0000000E 01	6.1725917E-05	2.7970001E 03	2.5957751E-01	3.8508176E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP / Y**2 / NU	POWER LOSS / EPSTEIN CO / GROUP DELAY
6.8000000E 03	9.0156168E 03	1.1497856E 02	8.9999987E 01	9.9229129E-01	-0.0000000E-39	0.0000000E-39
1.2103340E 04	5.1523870E-01	-5.5164032E-01	0.0000000E-39	5.6977799E-01	5.6977797E-01	1.8135833E-08
7.8857478E 03	1.0000005E 00	9.0000000E 01	2.7363268E-05	2.3380222E 03	6.6140081E-02	4.0344465E 01
7.0000000E 03	9.1865203E 03	1.1364169E 02	8.9999987E 01	9.9227326E-01	-0.0000000E-39	0.0000000E-39
1.2501771E 04	5.3484138E-01	-6.0856353E-01	0.0000000E-39	5.5640713E-01	5.5640711E-01	3.4927727E-09
8.1405925E 03	1.0000011E 00	9.0000000E 01	1.8864516E-05	2.0527903E 03	2.0200305E-02	4.1672571E 01
7.2000000E 03	9.3428774E 03	1.1236562E 02	8.9999987E 01	9.9226943E-01	-0.0000000E-39	0.0000000E-39
1.2839439E 04	5.3739858E-01	-6.5042619E-01	0.0000000E-39	7.1185149E-01	7.1185146E-01	8.4830332E-10
8.3821237E 03	1.0000011E 00	9.0000000E 01	1.4668803E-05	1.8522921E 03	6.8261424E-03	4.2798130E 01
7.4000000E 03	9.4086642E 03	1.1112181E 02	8.9999987E 01	9.9226944E-01	-0.0000000E-39	0.0000000E-39
1.3144621E 04	5.3027412E-01	-6.8496159E-01	0.0000000E-39	7.5036305E-01	7.5036303E-01	2.3900814E-10
8.6158774E 03	1.0000002E 00	9.0000000E 01	1.2373409E-05	1.7025110E 03	2.4826449E-03	4.3815402E 01
7.6000000E 03	9.6256927E 03	1.0989641E 02	8.9999987E 01	9.9226815E-01	-0.0000000E-39	0.0000000E-39
1.3429806E 04	5.1701558E-01	-7.1503410E-01	0.0000000E-39	7.7857886E-01	7.7857887E-01	7.5191972E-11
8.8445264E 03	1.0000000E 00	9.0000000E 01	1.1996634E-05	1.5860124E 03	9.5962344E-04	4.4766021E 01
7.8000000E 03	9.7548459E 03	1.0866143E 02	8.9999987E 01	9.9226805E-01	-0.0000000E-39	0.0000000E-39
1.3701579E 04	5.0027035E-01	-7.4147620E-01	0.0000000E-39	8.0005740E-01	8.0005737E-01	2.5883834E-11
9.0895828E 03	1.0000002E 00	9.0000000E 01	1.3450141E-05	1.4926772E 03	3.9179893E-04	4.5671929E 01
8.0000000E 03	9.8764929E 03	1.0747157E 02	8.9999987E 01	9.9226802E-01	-0.0000000E-39	0.0000000E-39
1.3963811E 04	4.8166565E-01	-7.6475966E-01	0.0000000E-39	8.1687841E-01	8.1687840E-01	9.6408418E-12
9.2919745E 03	1.0000000E 00	9.0000000E 01	1.4730776E-05	1.4162188E 03	1.6853182E-04	4.6546037E 01
8.2000000E 03	9.9907505E 03	1.0626334E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4218965E 04	4.6044391E-01	-7.8634090E-01	0.0000000E-39	8.3034061E-01	8.3034059E-01	3.8600900E-12
9.5123236E 03	1.0000005E 00	9.0000000E 01	1.3540360E-05	1.3525142E 03	7.6312902E-05	4.7396548E 01
8.4000000E 03	9.0977012E 03	1.0503471E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4466698E 04	4.3511170E-01	-8.0745301E-01	0.0000000E-39	8.4130257E-01	8.4130255E-01	1.6537542E-12
9.7310636E 03	1.0000001E 00	9.0000000E 01	1.2090531E-05	1.2987091E 03	3.6354116E-05	4.8228992E 01
8.6000000E 03	9.1973750E 03	1.0384443E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4714182E 04	4.0094400E-01	-8.2749397E-01	0.0000000E-39	8.5034970E-01	8.5034967E-01	7.5573527E-13
9.9485109E 03	1.0000001E 00	9.0000000E 01	1.3019496E-05	1.2527913E 03	1.8215836E-05	4.9047273E 01
8.8000000E 03	9.2896003E 03	1.0263119E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4956275E 04	3.7851059E-01	-8.4534718E-01	0.0000000E-39	8.5788213E-01	8.5788211E-01	3.6805543E-13
1.0164904E 04	1.0000000E 00	9.0000000E 01	1.5211265E-05	1.2133721E 03	9.6116026E-06	4.9854250E 01
9.0000000E 03	9.3740654E 03	1.0141391E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5195626E 04	3.4918459E-01	-8.6154041E-01	0.0000000E-39	8.6418176E-01	8.6418173E-01	1.9115900E-13
1.0380430E 04	1.0000003E 00	9.0000000E 01	1.4742595E-05	1.1794698E 03	5.3521560E-06	5.0652088E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CO
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
9.2000000E 03	9.4506141E 03	1.0019236E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5432741E 04	3.1603229E-01	-8.7726200E-01	0.0000000E-39	8.6946503E-01	8.6946501E-01	1.0586332E-13
1.0595236E 04	1.0000000E 00	9.0000000E 01	1.3205466E-05	1.1502943E 03	3.1485539E-06	5.1442470E 01
9.4000000E 03	9.5191812E 03	9.8966667E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5668024E 04	2.8045148E-01	-8.9176531E-01	0.0000000E-39	8.7389839E-01	8.7389839E-01	6.2476631E-14
1.0809443E 04	1.0000001E 00	9.0000000E 01	1.4332095E-05	1.1252157E 03	1.9576336E-06	5.2226745E 01
9.6000000E 03	9.5794746E 03	9.7736665E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5901805E 04	2.4564439E-01	-9.0402183E-01	0.0000000E-39	8.7759665E-01	8.7759663E-01	3.9345983E-14
1.1023154E 04	9.9999999E-01	9.0000000E 01	1.6199269E-05	1.1038191E 03	1.2890357E-06	5.3006017E 01
9.8000000E 03	9.6311339E 03	9.6502371E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6134363E 04	2.0972222E-01	-9.1469123E-01	0.0000000E-39	8.8064346E-01	8.8064346E-01	2.6495707E-14
1.1236456E 04	1.0000002E 00	9.0000000E 01	1.4973576E-05	1.0858098E 03	9.0114630E-07	5.3781209E 01
1.0000000E 04	9.6740923E 03	9.5264431E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6365933E 04	1.7014555E-01	-9.2421018E-01	0.0000000E-39	8.8311398E-01	8.8311397E-01	1.9077606E-14
1.1449423E 04	9.9999999E-01	9.0000000E 01	1.4074001E-05	1.0708869E 03	6.6914065E-07	5.4553111E 01
1.0200000E 04	9.7082855E 03	9.4023462E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6596725E 04	1.3017139E-01	-9.3172966E-01	0.0000000E-39	8.8506474E-01	8.8506474E-01	1.4688242E-14
1.1662125E 04	1.0000001E 00	9.0000000E 01	1.5889954E-05	1.0588213E 03	5.2798227E-07	5.5322417E 01
1.0400000E 04	9.7334000E 03	9.2779930E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6826925E 04	9.1694817E-02	-9.3707988E-01	0.0000000E-39	8.8652664E-01	8.8652664E-01	1.2117002E-14
1.1874623E 04	1.0000001E 00	9.0000000E 01	1.6450377E-05	1.0495130E 03	4.4365498E-07	5.6089748E 01
1.0600000E 04	9.7492821E 03	9.1534641E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7056702E 04	5.1120044E-02	-9.4069759E-01	0.0000000E-39	8.8752522E-01	8.8752520E-01	1.0720111E-14
1.2086973E 04	1.0000001E 00	9.0000000E 01	1.4713411E-05	1.0428664E 03	3.9742639E-07	5.6855673E 01
1.0800000E 04	9.7560507E 03	9.0288507E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7286218E 04	8.6260205E-03	-9.4234359E-01	0.0000000E-39	8.8808585E-01	8.8808583E-01	1.0160932E-14
1.2299230E 04	1.0000001E 00	9.0000000E 01	1.5072413E-05	1.0387583E 03	3.7922009E-07	5.7620725E 01
1.0846431E 04	9.7562743E 03	8.9999169E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7339479E 04	4.2585988E-07	-9.4241841E-01	0.0000000E-39	8.8815248E-01	8.8815246E-01	1.0138060E-14
1.2348498E 04	9.9999999E-01	9.0000000E 01	1.4537934E-05	1.0381770E 03	3.7863385E-07	5.7798265E 01

RDOT = -0.107819E-09

1.1000000E 04	9.7536423E 03	8.9042212E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7515668E 04	-3.1898650E-02	-9.4171371E-01	0.0000000E-39	8.8784222E-01	8.8784222E-01	1.0361183E-14
1.2511463E 04	1.0000000E 00	9.0000000E 01	1.6747733E-05	1.0406271E 03	3.8560248E-07	5.8385561E 01
1.1200000E 04	9.7418979E 03	8.7796435E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7745306E 04	-7.1292518E-02	-9.3912849E-01	0.0000000E-39	8.8704495E-01	8.8704494E-01	1.1350454E-14
1.2723764E 04	1.0000001E 00	9.0000000E 01	1.5730328E-05	1.0461123E 03	4.1829643E-07	5.9151019E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP / Y**2 / NU	POWER LOSS / EPSTEIN CO / GROUP DELAY
1.1400000E 04	9.7209622E 03	8.6552052E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7975289E 04	-1.1268877E-01	-9.3439713E-01	0.0000000E-39	8.8579676E-01	8.8579675E-01	1.3329988E-14
1.2936186E 04	9.9999999E-01	9.0000000E 01	1.4286140E-05	1.0542007E 03	4.8360261E-07	5.9917629E 01
1.1600000E 04	9.6910646E 03	8.5309726E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8205784E 04	-1.5330173E-01	-9.2767429E-01	0.0000000E-39	8.8408103E-01	8.8408101E-01	1.6756885E-14
1.3148786E 04	1.0000002E 00	9.0000000E 01	1.5562217E-05	1.0649434E 03	5.9492356E-07	6.0685947E 01
1.1800000E 04	9.6521852E 03	8.4070248E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8436970E 04	-1.9067842E-01	-9.1951088E-01	0.0000000E-39	8.8185852E-01	8.8185851E-01	2.2557459E-14
1.3361623E 04	1.0000000E 00	9.0000000E 01	1.6231197E-05	1.0785101E 03	7.7887334E-07	6.1456567E 01
1.2000000E 04	9.6044097E 03	8.2834369E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8669043E 04	-2.2796770E-01	-9.0945650E-01	0.0000000E-39	8.7908041E-01	8.7908038E-01	3.2509142E-14
1.3574761E 04	1.0000001E 00	9.0000000E 01	1.4323911E-05	1.0950981E 03	1.0845563E-06	6.2230144E 01
1.2200000E 04	9.5480913E 03	8.1602352E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8902226E 04	-2.6574545E-01	-8.9725860E-01	0.0000000E-39	8.7569367E-01	8.7569363E-01	5.0049374E-14
1.3788272E 04	1.0000001E 00	9.0000000E 01	1.3952774E-05	1.1148888E 03	1.6023384E-06	6.3007420E 01
1.2400000E 04	9.4834436E 03	8.0374426E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.9136776E 04	-3.0061479E-01	-8.8388356E-01	0.0000000E-39	8.7161943E-01	8.7161939E-01	8.2231394E-14
1.4002238E 04	1.0000001E 00	9.0000000E 01	1.5438533E-05	1.1381775E 03	2.5080389E-06	6.3789254E 01
1.2600000E 04	9.4105314E 03	7.9151016E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.9372998E 04	-3.3262481E-01	-8.6954340E-01	0.0000000E-39	8.6674502E-01	8.6674499E-01	1.4422660E-13
1.4216753E 04	1.0000000E 00	9.0000000E 01	1.4930436E-05	1.1654038E 03	4.1572354E-06	6.4576659E 01
1.2800000E 04	9.3696013E 03	7.7932055E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.9611258E 04	-3.6454452E-01	-8.5325250E-01	0.0000000E-39	8.6093255E-01	8.6093253E-01	2.6979289E-13
1.4431929E 04	1.0000000E 00	9.0000000E 01	1.3085780E-05	1.1970722E 03	7.2849621E-06	6.5370858E 01
1.3000000E 04	9.2409858E 03	7.6710922E 01	8.9999987E 01	9.9226799E-01	-0.0000000E-39	0.0000000E-39
1.9852010E 04	-3.9545574E-01	-8.3523580E-01	0.0000000E-39	8.5400409E-01	8.5400407E-01	5.3755009E-13
1.4647900E 04	1.0000002E 00	9.0000000E 01	1.3208324E-05	1.2338120E 03	1.3464953E-05	6.6173367E 01
1.3200000E 04	9.1448372E 03	7.5505080E 01	8.9999987E 01	9.9226799E-01	-0.0000000E-39	0.0000000E-39
2.0095832E 04	-4.2300777E-01	-8.1650098E-01	0.0000000E-39	8.4570742E-01	8.4570740E-01	1.1412095E-12
1.4864833E 04	1.0000001E 00	9.0000000E 01	1.4492756E-05	1.2765319E 03	2.6223182E-05	6.6986106E 01
1.3400000E 04	9.0412130E 03	7.4295930E 01	8.9999987E 01	9.9226799E-01	-0.0000000E-39	0.0000000E-39
2.0343475E 04	-4.4767079E-01	-7.9704476E-01	0.0000000E-39	8.3568950E-01	8.3568949E-01	2.5853932E-12
1.5082941E 04	1.0000000E 00	9.0000000E 01	1.4017018E-05	1.3264913E 03	5.3790262E-05	6.7811584E 01
1.3600000E 04	8.9302416E 03	7.3088099E 01	8.9999987E 01	9.9226798E-01	-0.0000000E-39	0.0000000E-39
2.0595948E 04	-4.7114927E-01	-7.7552903E-01	0.0000000E-39	8.2346261E-01	8.2346258E-01	6.2601688E-12
1.5302499E 04	1.0000000E 00	9.0000000E 01	1.2434426E-05	1.3853692E 03	1.1611286E-04	6.8653159E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP / Y**2 / NU	POWER LOSS / EPSTEIN CO / GROUP DELAY
1.3800000E 04	8.8120227E 03	7.1879375E 01	8.9999987E 01	9.9226796E-01	-0.0000000E-39	0.0000000E-39
2.0854655E 04	-4.9289190E-01	-7.5191908E-01	0.0000000E-39	8.0832474E-01	8.0832472E-01	1.6244030E-11
1.5523881E 04	1.0000001E 00	9.0000000E 01	1.2113422E-05	1.4555074E 03	2.6358472E-04	6.9515514E 01
1.4000000E 04	8.6864583E 03	7.0666925E 01	8.9999987E 01	9.9226790E-01	-0.0000000E-39	0.0000000E-39
2.1121633E 04	-5.1118992E-01	-7.2656618E-01	0.0000000E-39	7.8921355E-01	7.8921354E-01	4.5419231E-11
1.5747610E 04	1.0000003E 00	9.0000000E 01	1.3231398E-05	1.5403513E 03	6.2969025E-04	7.0405443E 01
1.4200000E 04	8.5532037E 03	6.9446842E 01	8.9999987E 01	9.9226773E-01	-0.0000000E-39	0.0000000E-39
2.1399999E 04	-5.2500870E-01	-6.9915876E-01	0.0000000E-39	7.6445711E-01	7.6445710E-01	1.3816030E-10
1.5974452E 04	1.0000001E 00	9.0000000E 01	1.4497929E-05	1.6451040E 03	1.5868946E-03	7.1333328E 01
1.4400000E 04	8.4115997E 03	6.8212914E 01	8.9999987E 01	9.9226717E-01	-0.0000000E-39	0.0000000E-39
2.1694843E 04	-5.3382881E-01	-6.6807187E-01	0.0000000E-39	7.3129323E-01	7.3129321E-01	4.6449985E-10
1.6205602E 04	1.0000000E 00	9.0000000E 01	1.5111310E-05	1.7778818E 03	4.2381968E-03	7.2316142E 01
1.4600000E 04	8.2603882E 03	6.6954459E 01	8.9999987E 01	9.9226516E-01	-0.0000000E-39	0.0000000E-39
2.2015295E 04	-5.3594627E-01	-6.3053519E-01	0.0000000E-39	6.8481304E-01	6.8481303E-01	1.7747449E-09
1.6443082E 04	1.0000000E 00	9.0000000E 01	1.6286408E-05	1.9520851E 03	1.2101202E-02	7.3384317E 01
1.4800000E 04	8.0969135E 03	6.5651290E 01	8.9999987E 01	9.9225663E-01	-0.0000000E-39	0.0000000E-39
2.2380177E 04	-5.2627038E-01	-5.8162571E-01	0.0000000E-39	6.1524900E-01	6.1524897E-01	8.1507641E-09
1.6690746E 04	9.9999999E-01	9.0000000E 01	2.0763987E-05	2.1921001E 03	3.7627766E-02	7.4600591E 01
1.5000000E 04	7.9145271E 03	6.4256299E 01	8.9999987E 01	9.9220926E-01	-0.0000000E-39	0.0000000E-39
2.2839184E 04	-4.9049036E-01	-5.0817310E-01	0.0000000E-39	4.9882070E-01	4.9882069E-01	5.1968114E-08
1.6957711E 04	1.0000000E 00	9.0000000E 01	3.6778884E-05	2.5517022E 03	1.3343921E-01	7.6130611E 01
1.5200000E 04	7.6847656E 03	6.2571919E 01	8.9999987E 01	9.9166191E-01	-0.0000000E-39	0.0000000E-39
2.3653292E 04	-3.4888537E-01	-3.3667156E-01	0.0000000E-39	2.3506A75E-01	2.3506A74E-01	9.9657889E-07
1.7282348E 04	1.0000003E 00	9.0000000E 01	2.0589124E-04	3.2418612E 03	6.5767968E-01	7.8844307E 01
MAIN EMUS = -0.35763E-06						
1.5252622E 04	7.5721335E 03	6.1769220E 01	8.9999987E 01	9.8841253E-01	0.0000000E-39	0.0000000E-39
2.4828140E 04	8.6445506E-05	-2.3048930E-04	-0.0000000E-39	-3.5762787E-07	6.0598143E-08	2.1926464E 00
1.7437619E 04	2.4903268E 00	9.0000010E 01	-1.9078991E 05	3.7784719E 03	1.4376653E 00	8.2760466E 01

C

INITIAL RAY POSITION

RO	9295.19
THETAO	77.44
PHIO	90.00

INITIAL RAY DIRECTION

AO	65.99
BO	0.00
DELAO	0.00

RAY CHARACTERISTICS

FREQ	1.00
MODE	-1

FIELD LINE

LAMBDA	53.94
L-VALUE	1.53

STOP CONDITIONS

	MAX	MIN
RADIUS	20000.0	6378.0
THETA	180.0	0.0
PHI	360.0	0.0

INTERVALS

PRINT	200.0
PLOT	100.0
STEP	20.0

PROGRAM OPTIONS

NPOWER	0
NPLOT	1
NOVER	0
NAUTO	0
JTEST	2

OTHER INITIAL VALUES

SCALE SIZE	0.707
PKFRAC	0.050
HPRIME	1.176
PKDELN	60.553

C

PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CO
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
2.0000000E 01	0.3039232E 03	7.7566594E 01	8.9999987E 01	9.9999999E-01	0.0000000E-39	0.0000000E-39
2.4032085E 01	3.7294975E-01	8.4846694E-01	-0.0000000E-39	8.5898767E-01	8.5898766E-01	3.2931667E-13
2.1583472E 01	1.0000002E 00	-9.0000000E 01	1.6469652E-05	1.2074858E 03	8.7041584E-06	8.0106949E-02
2.0000000E 02	0.3790900E 03	7.8662731E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3919744E 02	3.4836922E-01	8.6207860E-01	0.0000000E-39	8.6454064E-01	8.6454062E-01	1.8389052E-13
2.1547629E 02	1.0000012E 00	-9.0000000E 01	1.4166274E-05	1.1775117E 03	5.1695189E-06	7.9732478E-01
4.0000000E 02	0.4551005E 03	7.9884624E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.7618564E 02	3.1347375E-01	8.7834971E-01	0.0000000E-39	8.6976400E-01	8.6976399E-01	1.0227621E-13
4.3024089E 02	0.9999999E-01	-9.0000000E 01	1.1866743E-05	1.1486229E 03	3.0524584E-06	1.5872855E 00
6.0000000E 02	0.5232367E 03	8.1110411E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
7.1136462E 02	2.7713870E-01	8.9294265E-01	0.0000000E-39	8.7415246E-01	8.7415243E-01	6.0566377E-14
6.4441425E 02	1.0000007E 00	-9.0000000E 01	1.5025012E-05	1.1237602E 03	1.9035364E-06	2.3712154E 00
8.0000000E 02	0.5830220E 03	8.2340661E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
9.4506214E 02	2.4415679E-01	9.0454189E-01	0.0000000E-39	8.7780859E-01	8.7780856E-01	3.8294271E-14
8.5809727E 02	1.0000001E 00	-9.0000000E 01	1.7477239E-05	1.1025771E 03	1.2578231E-06	3.1502071E 00
1.0000000E 03	0.6340448E 03	8.3575341E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.1775512E 03	2.0817369E-01	9.1513752E-01	0.0000000E-39	8.8081297E-01	8.8081296E-01	2.5913750E-14
1.0713757E 03	1.0000007E 00	-9.0000000E 01	1.3846845E-05	1.0847974E 03	8.8320766E-07	3.9251707E 00
1.2000000E 03	0.6764625E 03	8.4813458E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.4090666E 03	1.6666775E-01	9.2491707E-01	0.0000000E-39	8.8324974E-01	8.8324972E-01	1.8735864E-14
1.2843248E 03	1.0000002E 00	-9.0000000E 01	1.3299936E-05	1.0700573E 03	6.5827430E-07	4.6968887E 00
1.4000000E 03	0.7101851E 03	8.6054524E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.6398160E 03	1.2717220E-01	9.3220177E-01	0.0000000E-39	8.8517293E-01	8.8517290E-01	1.4476953E-14
1.4970122E 03	1.0000003E 00	-9.0000000E 01	1.7301383E-05	1.0581417E 03	5.2109726E-07	5.4660533E 00
1.6000000E 03	0.7346810E 03	8.7298237E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.8699844E 03	0.0446675E-02	9.3724206E-01	0.0000000E-39	8.8660328E-01	8.8660327E-01	1.1998679E-14
1.7094991E 03	1.0000006E 00	-9.0000000E 01	1.6676506E-05	1.0490151E 03	4.3974591E-07	6.2332812E 00
1.8000000E 03	0.7499128E 03	8.8543625E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.0997405E 03	4.8520172E-02	9.4085938E-01	0.0000000E-39	8.8757059E-01	8.8757058E-01	1.0667616E-14
1.9218418E 03	1.0000000E 00	-9.0000000E 01	1.3323439E-05	1.0425515E 03	3.9570018E-07	6.9991349E 00
2.0000000E 03	0.7561775E 03	8.9789761E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3292446E 03	4.7936449E-03	9.4238210E-01	0.0000000E-39	8.8810702E-01	8.8810700E-01	1.0149667E-14
2.1340945E 03	1.0000007E 00	-9.0000000E 01	1.5319731E-05	1.0385822E 03	3.7888778E-07	7.7641487E 00
2.0260837E 03	0.7562467E 03	8.9952306E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3591659E 03	-2.4456811E-05	9.4241296E-01	0.0000000E-39	8.8814222E-01	8.8814219E-01	1.0141084E-14
2.1617723E 03	1.0000004E 00	-9.0000000E 01	1.4083907E-05	1.0382693E 03	3.7870657E-07	7.8638863E 00

RDOT = -0.3243655E-09

C

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP / Y**2 / NU	POWER LOSS / EPSTEIN CO / GROUP DELAY
2.2000000E 03	9.7532346E 03	9.1036867E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.5587015E 03	-3.3936011E-02	9.4162404E-01	0.0000000E-39	8.8780750E-01	8.8780747E-01	1.0394681E-14
2.3463297E 03	9.9999999E-01	-9.0000000E 01	1.8152613E-05	1.0408803E 03	3.8668870E-07	8.5290051E 00
2.4000000E 03	9.7408164E 03	9.2281754E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.7883557E 03	-7.2818894E-02	9.3897601E-01	0.0000000E-39	8.8697855E-01	8.8697854E-01	1.1445093E-14
2.5586364E 03	1.0000006E 00	-9.0000000E 01	1.4817140E-05	1.0465529E 03	4.2143457E-07	9.2945191E 00
2.6000000E 03	9.7193019E 03	9.3526001E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.0183659E 03	-1.1610567E-01	9.3592753E-01	0.0000000E-39	8.8570116E-01	8.8570115E-01	1.3500052E-14
2.7710682E 03	1.0000001E 00	-9.0000000E 01	1.3307696E-05	1.0548087E 03	4.8918262E-07	1.0061220E 01
2.8000000E 03	9.6889330E 03	9.4766252E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.2486991E 03	-1.5647718E-01	9.2707807E-01	0.0000000E-39	8.8395886E-01	8.8395885E-01	1.7031583E-14
2.9836812E 03	1.0000005E 00	-9.0000000E 01	1.6809964E-05	1.0656973E 03	6.0374732E-07	1.0829664E 01
3.0000000E 03	9.6494663E 03	9.6007515E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.4801351E 03	-1.9188669E-01	9.1917433E-01	0.0000000E-39	8.8170196E-01	8.8170195E-01	2.3030040E-14
3.1965352E 03	1.0000004E 00	-9.0000000E 01	1.6751295E-05	1.0704545E 03	7.9364087E-07	1.1600450E 01
3.2000000E 03	9.6010636E 03	9.7243036E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.7122710E 03	-2.3005522E-01	9.0882241E-01	0.0000000E-39	8.7888360E-01	8.7888357E-01	3.3349983E-14
3.4096945E 03	1.0000001E 00	-9.0000000E 01	1.2921440E-05	1.0962617E 03	1.1099250E-06	1.2374237E 01
3.4000000E 03	9.5442659E 03	9.8474867E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.9455315E 03	-2.6915673E-01	8.9611009E-01	0.0000000E-39	8.7545864E-01	8.7545863E-01	5.1535437E-14
3.6232317E 03	1.0000007E 00	-9.0000000E 01	1.3783289E-05	1.1162475E 03	1.6452545E-06	1.3151772E 01
3.6000000E 03	9.4791589E 03	9.9702653E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.1801774E 03	-3.0266168E-01	8.8502022E-01	0.0000000E-39	8.7134092E-01	8.7134090E-01	8.4979735E-14
3.8372293E 03	1.0000001E 00	-9.0000000E 01	1.6982257E-05	1.1397493E 03	2.5833914E-06	1.3933925E 01
3.8000000E 03	9.4056719E 03	1.0092505E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.4165156E 03	-3.3354193E-01	8.6899855E-01	0.0000000E-39	8.6640873E-01	8.6640869E-01	1.4972562E-13
4.0517824E 03	1.0000006E 00	-9.0000000E 01	1.4573974E-05	1.1672594E 03	4.2992075E-06	1.4721719E 01
4.0000000E 03	9.3242083E 03	1.0214423E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.6549172E 03	-3.6072053E-01	8.5206294E-01	0.0000000E-39	8.6052931E-01	8.6052927E-01	2.8128736E-13
4.2670035E 03	9.9999999E-01	-9.0000000E 01	1.1754524E-05	1.1992414E 03	7.5616214E-06	1.5516391E 01
4.2000000E 03	9.2951743E 03	1.0335929E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.8958437E 03	-3.9829176E-01	8.3360097E-01	0.0000000E-39	8.5352691E-01	8.5352689E-01	5.6242231E-13
4.4830295E 03	1.0000009E 00	-9.0000000E 01	1.3437236E-05	1.2363054E 03	1.4016773E-05	1.6319479E 01
4.4000000E 03	9.1385934E 03	1.0457108E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.1398819E 03	-4.2449239E-01	8.1544024E-01	0.0000000E-39	8.4513658E-01	8.4513656E-01	1.1984651E-12
4.7000301E 03	1.0000000E 00	-9.0000000E 01	1.5997801E-05	1.2794220E 03	2.7379573E-05	1.7132940E 01

C

PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CO
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
4.6000000E 03	6.0344534E 03	1.0577993E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.3877957E 03	-6.4820698E-01	7.9630570E-01	0.0000000E-39	8.3499229E-01	8.3499227E-01	2.7273660E-12
4.9182202E 03	1.0000006E 00	-9.0000000E 01	1.3783368E-05	1.3299086E 03	5.6363433E-05	1.7959319E 01
4.8000000E 03	8.9229851E 03	1.0698758E 02	8.9999987E 01	9.9999998E-01	-0.0000000E-39	0.0000000E-39
5.6406133E 03	-4.7247833E-01	7.7418749E-01	0.0000000E-39	8.2260205E-01	8.2260203E-01	6.6340648E-12
5.1378809E 03	1.0000000E 00	-9.0000000E 01	1.1102887E-05	1.3894372E 03	1.2208703E-04	1.8802044E 01
5.0000000E 03	8.8043370E 03	1.0819654E 02	8.9999987E 01	9.9999996E-01	-0.0000000E-39	0.0000000E-39
5.8997706E 03	-6.9495025E-01	7.4985154E-01	0.0000000E-39	8.0725309E-01	8.0725307E-01	1.7287982E-11
5.3593929E 03	1.0000007E 00	-9.0000000E 01	1.1611349E-05	1.4603705E 03	2.7797160E-04	1.9665902E 01
5.2000000E 03	8.6783485E 03	1.0940955E 02	8.9999987E 01	9.9999990E-01	-0.0000000E-39	0.0000000E-39
6.1673580E 03	-5.1280068E-01	7.2449033E-01	0.0000000E-39	7.8785077E-01	7.8785077E-01	4.8560328F-11
5.5832910E 03	1.0000010E 00	-9.0000000E 01	1.4284647E-05	1.5462582E 03	6.6601317E-04	2.0557860E 01
5.4000000E 03	8.5445992E 03	1.1063033E 02	8.9999987E 01	9.9999971E-01	-0.0000000E-39	0.0000000E-39
6.4465814E 03	-5.2537873E-01	6.9759721E-01	0.0000000E-39	7.6266468E-01	7.6266467E-01	1.4855589E-10
5.8103626E 03	9.9999999E-01	-9.0000000E 01	1.5901231E-05	1.6524843E 03	1.6842028E-03	2.1488604E 01
5.6000000E 03	8.4024056E 03	1.1186527E 02	8.9999987E 01	9.9999911E-01	-0.0000000E-39	0.0000000E-39
6.7427059E 03	-5.3338426E-01	6.6658556E-01	0.0000000E-39	7.2883508E-01	7.2883508E-01	5.0310463E-10
6.0418395E 03	1.0000006E 00	-9.0000000E 01	1.5228258E-05	1.7874207E 03	4.5165364E-03	2.2475686E 01
5.8000000E 03	8.2504941E 03	1.1312562E 02	8.9999987E 01	9.9999690E-01	-0.0000000E-39	0.0000000E-39
7.0652397E 03	-5.3525086E-01	6.2830439E-01	0.0000000E-39	6.8125990E-01	6.8125989E-01	1.9409943E-09
6.2798168E 03	1.0000005E 00	-9.0000000E 01	1.5642431E-05	1.9649102E 03	1.2958793E-02	2.3550799E 01
6.0000000E 03	8.0860879E 03	1.1443262E 02	8.9999987E 01	9.9998741E-01	-0.0000000E-39	0.0000000E-39
7.4340067E 03	-5.2499031E-01	5.7799308E-01	0.0000000E-39	6.0969083E-01	6.0969082E-01	9.0477102E-09
6.5283325E 03	1.0000000E 00	-9.0000000E 01	2.0518218E-05	2.2103736E 03	4.0555973E-02	2.4780022E 01
6.2000000E 03	7.9020624E 03	1.1583653E 02	8.9999987E 01	9.9993349E-01	-0.0000000E-39	0.0000000E-39
7.9025547E 03	-4.8676638E-01	5.0175183E-01	0.0000000E-39	4.8869641E-01	4.8869640E-01	5.9504748E-08
6.7971226E 03	1.0000003E 00	-9.0000000E 01	3.8403949E-05	2.5809750E 03	1.4547056E-01	2.6341849E 01
6.4000000E 03	7.6653594E 03	1.1756683E 02	8.9999987E 01	9.9923335E-01	-0.0000000E-39	0.0000000E-39
8.7833248E 03	-3.2390833E-01	3.1156787E-01	0.0000000E-39	2.0199116E-01	2.0199115E-01	1.4098117E-06
7.1307551E 03	1.0000021E 00	-9.0000000E 01	2.7638541E-04	3.3205346E 03	7.5239098E-01	2.9277749E 01
6.4400566E 03	7.5721304E 03	1.1823051E 02	8.9999987E 01	9.9611150E-01	-0.0000000E-39	0.0000000E-39
9.8577780E 03	4.8961587E-04	1.0878130E-03	0.0000000E-39	1.4230609E-06	1.4230609E-06	9.2317578E-01
7.2591330E 03	2.9313798E 00	-8.9999988E 01	3.9348341E 04	3.7784882E 03	1.4374013E 00	3.2859260E 01

ROOT = 0.119733E 03

6.6000000E 03	7.8181928E 03	1.1645444E 02	8.9999987E 01	9.9242402E-01	-0.0000000E-39	0.0000000E-39
1.1549916E 04	4.5106217E-01	-4.5505125E-01	0.0000000E-39	4.1052873E-01	4.1052872E-01	1.5544319E-07
7.6019037E 03	1.0000016E 00	9.0000000E 01	5.9383944E-05	2.7982431E 03	2.6039533E-01	3.8499721E 01

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PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION = MOD AND ARG	COLATITUDE / Y2 / DEL MU	LONGITUDE / Y3 / N	ABSORPTION / MU**2 / NU	DOPPLER SP / Y**2	POWER LOSS / EPSTEIN CO / GROUP DELAY
6.8000000E 03	6.0153330E 03	1.1497758E 02	8.9999987E 01	9.9229947E-01	-0.0000000E-39	0.0000000E-39
1.2100996E 04	5.1097861E-01	-5.5545428E-01	0.0000000E-39	5.6963304E-01	5.6963303E-01	1.8184772E-08
7.8857042E 03	1.0000138E 00	9.0000000E 01	2.3742982E-05	2.3385556E 03	6.6271536E-02	4.0336654E 01
7.0000000E 03	6.1665252E 03	1.1364226E 02	8.9999987E 01	9.9228141E-01	-0.0000000E-39	0.0000000E-39
1.2499484E 04	5.2885737E-01	-6.1377509E-01	0.0000000E-39	6.5640998E-01	6.5640996E-01	3.4926194E-09
8.1405604E 03	1.0000194E 00	9.0000000E 01	2.0575027E-05	2.0527854E 03	2.0199563E-02	4.1664945E 01
7.2000000E 03	6.3430880E 03	1.1236723E 02	8.9999987E 01	9.9227757E-01	-0.0000000E-39	0.0000000E-39
1.2837181E 04	5.3702185E-01	-6.5077586E-01	0.0000000E-39	7.1190169E-01	7.1190167E-01	8.4680160E-10
8.3820966E 03	1.0000005E 00	9.0000000E 01	2.7577250E-05	1.8520632E 03	6.8160733E-03	4.2790603E 01
7.4000000E 03	6.4687042E 03	1.1112256E 02	8.9999987E 01	9.9227658E-01	-0.0000000E-39	0.0000000E-39
1.3142378E 04	5.3553221E-01	-6.8086596E-01	0.0000000E-39	7.5037321E-01	7.5037320E-01	2.3892542E-10
8.6158564E 03	1.0000195E 00	9.0000000E 01	1.4429818E-05	1.7024764E 03	2.4819458E-03	4.3807926E 01
7.6000000E 03	6.6654446E 03	1.0989553E 02	8.9999987E 01	9.9227629E-01	-0.0000000E-39	0.0000000E-39
1.3427567E 04	5.2057907E-01	-7.1241779E-01	0.0000000E-39	7.7854166E-01	7.7854166E-01	7.5342794E-11
8.8445085E 03	1.0000049E 00	9.0000000E 01	7.6741700E-06	1.5861974E 03	9.6128929E-04	4.4758558E 01
7.8000000E 03	6.7545413E 03	1.0866042E 02	8.9999987E 01	9.9227619E-01	-0.0000000E-39	0.0000000E-39
1.3699339E 04	4.9832508E-01	-7.4275952E-01	0.0000000E-39	8.0001961E-01	8.0001958E-01	2.5946676E-11
9.0695627E 03	1.0000030E 00	9.0000000E 01	7.2116479E-06	1.4928716E 03	3.9263385E-04	4.5664464E 01
8.0000000E 03	6.8764985E 03	1.0747194E 02	8.9999987E 01	9.9227616E-01	-0.0000000E-39	0.0000000E-39
1.3961574E 04	4.7590920E-01	-7.6836877E-01	0.0000000E-39	8.1688014E-01	8.1688013E-01	9.6403118E-12
9.2919552E 03	1.0000113E 00	9.0000000E 01	1.5808573E-05	1.4162165E 03	1.6852501E-04	4.6538579E 01
8.2000000E 03	6.9909630E 03	1.0626442E 02	8.9999987E 01	9.9227615E-01	-0.0000000E-39	0.0000000E-39
1.4216733E 04	4.6209006E-01	-7.8536670E-01	0.0000000E-39	8.3035952E-01	8.3035950E-01	3.8537134E-12
9.5123059E 03	1.0000026E 00	9.0000000E 01	2.2830800E-05	1.3524099E 03	7.6199617E-05	4.7389109E 01
8.4000000E 03	7.0975846E 03	1.0505457E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.4466469E 04	4.4025101E-01	-8.0465734E-01	0.0000000E-39	8.4129439E-01	8.4129438E-01	1.6552251E-12
9.7310469E 03	1.0000096E 00	9.0000000E 01	9.6646328E-06	1.2987617E 03	3.6383688E-05	4.8221563E 01
8.6000000E 03	7.1970591E 03	1.0384374E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.4711952E 04	4.0617660E-01	-8.2785741E-01	0.0000000E-39	8.5032735E-01	8.5032732E-01	7.5757118E-13
9.9484939E 03	1.0000006E 00	9.0000000E 01	6.8744184E-06	1.2529211E 03	1.8256042E-05	4.9039841E 01
8.8000000E 03	7.2896071E 03	1.0263151E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.4954046E 04	3.7270744E-01	-8.4792249E-01	0.0000000E-39	8.5788339E-01	8.5788337E-01	3.6803251E-13
1.0164887E 04	1.0000090E 00	9.0000000E 01	1.5956494E-05	1.2133702E 03	9.6111444E-06	4.9846818E 01
9.0000000E 03	7.3742843E 03	1.0141471E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5193400E 04	3.5167662E-01	-8.6053364E-01	0.0000000E-39	8.6419459E-01	8.6419458E-01	1.9084091E-13
1.0380414E 04	1.0000029E 00	9.0000000E 01	2.2390344E-05	1.1793927E 03	5.3439853E-06	5.0644666E 01

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PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CO
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
9.2000000E 03	9.4304237E 03	1.0019217E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5430516E 04	3.2061915E-01	-8.7559040E-01	0.0000000E-39	A.6945521E-01	A.6945518E-01	1.0601537E-13
1.0595220E 04	1.0000054E 00	9.0000000E 01	9.4049451E-06	1.1503586E 03	3.1527372E-06	5.1435053E 01
9.4000000E 03	9.5189124E 03	9.8966430E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5665797E 04	2.7722088E-01	-8.9276735E-01	0.0000000E-39	A.7388499E-01	A.7388496E-01	6.2603361E-14
1.0809427E 04	1.0000032E 00	9.0000000E 01	8.9807132E-06	1.1253020E 03	1.9613061E-06	5.2219324E 01
9.6000000E 03	9.5796604E 03	9.7737236E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5899580E 04	2.4152758E-01	-9.0513543E-01	0.0000000E-39	A.7760573E-01	A.7760571E-01	3.9290832E-14
1.1023138E 04	1.0000031E 00	9.0000000E 01	2.2039917E-05	1.1037627E 03	1.2873662E-06	5.2998599E 01
9.8000000E 03	9.6312145E 03	9.6502707E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6132139E 04	2.1531682E-01	-9.1339286E-01	0.0000000E-39	A.8064785E-01	A.8064783E-01	2.6479376E-14
1.1236441E 04	1.0000079E 00	9.0000000E 01	1.7245094E-05	1.0857864E 03	9.0064015E-07	5.3773798E 01
1.0000000E 04	9.6737740E 03	9.5264329E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6363710E 04	1.7132190E-01	-9.2398523E-01	0.0000000E-39	A.8309991E-01	A.8309988E-01	1.9123235E-14
1.1449408E 04	1.0000002E 00	9.0000000E 01	8.3066135E-06	1.0709788E 03	6.7062639E-07	5.4545699E 01
1.0200000E 04	9.7082472E 03	9.4023710E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6594501E 04	1.2416565E-01	-9.3254848E-01	0.0000000E-39	A.8506377E-01	A.8506377E-01	1.4692298E-14
1.1662110E 04	1.0000077E 00	9.0000000E 01	1.5133477E-05	1.0588326E 03	5.2812315E-07	5.5315002E 01
1.0400000E 04	9.7336588E 03	9.2780326E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6824702E 04	0.3664411E-02	-9.3689085E-01	0.0000000E-39	A.8653749E-01	A.8653748E-01	1.2093528E-14
1.1874608E 04	1.0000011E 00	9.0000000E 01	2.3721450E-05	1.0494419E 03	4.4285535E-07	5.6082339E 01
1.0600000E 04	9.7490923E 03	9.1534812E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7054480E 04	5.5869649E-02	-9.4042350E-01	0.0000000E-39	A.8751779E-01	A.8751777E-01	1.0735285E-14
1.2086959E 04	1.0000046E 00	9.0000000E 01	1.0955231E-05	1.0429188E 03	3.9795258E-07	5.6848267E 01
1.0800000E 04	9.7558131E 03	9.0288774E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7283994E 04	4.7762435E-03	-9.4236594E-01	0.0000000E-39	A.8807640E-01	A.8807637E-01	1.0178964E-14
1.2299215E 04	1.0000034E 00	9.0000000E 01	1.0382943E-05	1.0388236E 03	3.7984839E-07	5.7613314E 01
1.0862875E 04	9.7559785E 03	8.9896946E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7356121E 04	5.2858762E-05	-9.4240142E-01	0.0000000E-39	A.8812046E-01	A.8812044E-01	1.0162559E-14
1.2365933E 04	1.0000018E 00	9.0000000E 01	9.5427146E-06	1.0384425E 03	3.7941475E-07	5.7853736E 01
RDOT = 0.3046606E-09						
1.0862875E 04	9.7559785E 03	8.9896946E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7356121E 04	5.2858498E-05	-9.4240142E-01	0.0000000E-39	A.8812046E-01	A.8812044E-01	1.0162559E-14
1.2365933E 04	1.0000018E 00	9.0000000E 01	9.5427146E-06	1.0384425E 03	3.7941475E-07	5.7853736E 01
RDOT = 0.1126476E-10						
1.0862875E 04	9.7559785E 03	8.9896946E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7356121E 04	5.2858488E-05	-9.4240142E-01	0.0000000E-39	A.8812046E-01	A.8812044E-01	1.0162559E-14
1.2365933E 04	1.0000018E 00	9.0000000E 01	9.5427146E-06	1.0384425E 03	3.7941475E-07	5.7853736E 01
RDOT = -0.0000000E-38						

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PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION - MOD AND ARG	COLATITUDE Y2	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CO GROUP DELAY
1.1000000E 04	9.7936746E 03	8.9042443E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7513446E 04	-3.5245760E-02	-9.4159958E-01	0.0000000E-39	8.8785204E-01	8.8785202E-01	1.0343140E-14
1.2511448E 04	1.0000022E 00	9.0000000E 01	2.3012678E-05	1.0405631E 03	3.8497870E-07	5.8378152E 01
1.1200000E 04	9.7419417E 03	8.7796659E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7743084E 04	-2.5370599E-02	-9.3956067E-01	0.0000000E-39	8.8704756E-01	8.8704755E-01	1.1346602E-14
1.2723750E 04	1.0000074E 00	9.0000000E 01	1.6700121E-05	1.0460998E 03	4.1816919E-07	5.9143615E 01
1.1400000E 04	9.7206520E 03	8.6552647E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7973067E 04	-1.1458842E-01	-9.3440226E-01	0.0000000E-39	8.8578375E-01	8.8578374E-01	1.3360989E-14
1.2936172E 04	9.9999999E-01	9.0000000E 01	8.4944277E-06	1.0542867E 03	4.8464928E-07	5.9910223E 01
1.1600000E 04	9.6911000E 03	8.5310000E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.8203562E 04	-1.5918176E-01	-9.2686476E-01	0.0000000E-39	8.8408347E-01	8.8408346E-01	1.6752208E-14
1.3148771E 04	1.0000079E 00	9.0000000E 01	1.6225409E-05	1.0649328E 03	5.9477699E-07	6.0678538E 01
1.1800000E 04	9.6524272E 03	8.4070266E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.8434749E 04	-1.8763440E-01	-9.2014293E-01	0.0000000E-39	8.8186968E-01	8.8186967E-01	2.2516394E-14
1.3361609E 04	1.0000019E 00	9.0000000E 01	2.2908939E-05	1.0784390E 03	7.7756054E-07	6.1449163E 01
1.2000000E 04	9.6042000E 03	8.2834958E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.8666823E 04	-2.2398147E-01	-9.1044134E-01	0.0000000E-39	8.7907113E-01	8.7907112E-01	3.2560243E-14
1.3574747E 04	1.0000038E 00	9.0000000E 01	9.7715355E-06	1.0951607E 03	1.0861438E-06	6.2222742E 01
1.2200000E 04	9.5478989E 03	8.1600024E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.8900004E 04	-2.6985149E-01	-8.9602736E-01	0.0000000E-39	8.7568486E-01	8.7568486E-01	5.0121591E-14
1.3786258E 04	1.0000045E 00	9.0000000E 01	9.6153893E-06	1.1149483E 03	1.6044905E-06	6.3000012E 01
1.2400000E 04	9.4836815E 03	8.0374266E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9134554E 04	-3.0355927E-01	-8.8283398E-01	0.0000000E-39	8.7163236E-01	8.7163235E-01	8.2083085E-14
1.4002224E 04	1.0000027E 00	9.0000000E 01	2.2332335E-05	1.1380990E 03	2.5038823E-06	6.3781848E 01
1.2600000E 04	9.4105884E 03	7.9151181E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9370778E 04	-3.2702917E-01	-8.7166581E-01	0.0000000E-39	8.6674938E-01	8.6674935E-01	1.4416212E-13
1.4216740E 04	1.0000082E 00	9.0000000E 01	1.6083744E-05	1.1653835E 03	4.1555854E-06	6.4569258E 01
1.2800000E 04	9.3293307E 03	7.7933098E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9609036E 04	-3.6371978E-01	-8.5359492E-01	0.0000000E-39	8.6091638E-01	8.6091636E-01	2.7034880E-13
1.4431915E 04	1.0000002E 00	9.0000000E 01	7.2461871E-06	1.1971709E 03	7.2987398E-06	6.5363454E 01
1.3000000E 04	9.2409331E 03	7.6717456E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9849787E 04	-4.0062893E-01	-8.3276558E-01	0.0000000E-39	8.5400207E-01	8.5400204E-01	5.3775775E-13
1.4647885E 04	1.0000094E 00	9.0000000E 01	1.1260223E-05	1.2338320E 03	1.3469925E-05	6.6165956E 01
1.3200000E 04	9.1450950E 03	7.5506408E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
2.0093610E 04	-4.2357370E-01	-8.1627055E-01	0.0000000E-39	8.4572700E-01	8.4572698E-01	1.1389420E-12
1.4864819E 04	1.0000004E 00	9.0000000E 01	2.3405390E-05	1.2764207E 03	2.6176049E-05	6.6978700E 01

C

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
1.3400000E 04	9.0412096E 03	7.4296288E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
2.0341255E 04	-4.4229341E-01	-8.0004223E-01	0.0000000E-39	8.3569104E-01	8.3569102E-01	2.5854140E-12
1.5082927E 04	1.0000102E 00	9.0000000E 01	1.3188527E-05	1.3264922E 03	5.3791622E-05	6.7804183E 01
1.3600000E 04	8.9299915E 03	7.3089460E 01	8.9999987E 01	9.9227612E-01	-0.0000000E-39	0.0000000E-39
2.0593726E 04	-4.7049816E-01	-7.7593203E-01	0.0000000E-39	8.2343904E-01	8.2343902E-01	6.2723915E-12
1.5302485E 04	1.0000003E 00	9.0000000E 01	6.6921920E-06	1.3854996E 03	1.1631613E-04	6.8645753E 01
1.3800000E 04	8.8119235E 03	7.1880236E 01	8.9999987E 01	9.9227610E-01	-0.0000000E-39	0.0000000E-39
2.0852429E 04	-4.9729967E-01	-7.4900517E-01	0.0000000E-39	8.0831572E-01	8.0831569E-01	1.6256460E-11
1.5523866E 04	1.0000096E 00	9.0000000E 01	8.9132457E-06	1.4555654E 03	2.6376807E-04	6.9508097E 01
1.4000000E 04	8.6866577E 03	7.0666442E 01	8.9999987E 01	9.9227604E-01	-0.0000000E-39	0.0000000E-39
2.1119408E 04	-5.1445442E-01	-7.2427869E-01	0.0000000E-39	7.8924296E-01	7.8924296E-01	4.5345888E-11
1.5747595E 04	1.0000077E 00	9.0000000E 01	2.0426532E-05	1.5402129E 03	6.2881361E-04	7.0398026E 01
1.4200000E 04	8.5533727E 03	6.9446410E 01	8.9999987E 01	9.9227587E-01	-0.0000000E-39	0.0000000E-39
2.1397777E 04	-5.2098500E-01	-7.0218415E-01	0.0000000E-39	7.6448797E-01	7.6448794E-01	1.3796770E-10
1.5974438E 04	1.0000066E 00	9.0000000E 01	2.1027954E-05	1.6449653E 03	1.5850228E-03	7.1325923E 01
1.4400000E 04	8.4114847E 03	6.8213956E 01	8.9999987E 01	9.9227531E-01	-0.0000000E-39	0.0000000E-39
2.1692623E 04	-5.2955579E-01	-6.7144819E-01	0.0000000E-39	7.3127202E-01	7.3127200E-01	4.6493516E-10
1.6205589E 04	1.0000117E 00	9.0000000E 01	1.1226565E-05	1.7779944E 03	4.2416173E-03	7.2308743E 01
1.4600000E 04	8.2601404E 03	6.6956388E 01	8.9999987E 01	9.9227331E-01	-0.0000000E-39	0.0000000E-39
2.2013070E 04	-5.3554799E-01	-6.3081810E-01	0.0000000E-39	6.8474313E-01	6.8474312E-01	1.7785231E-09
1.6443067E 04	1.0000003E 00	9.0000000E 01	1.2084965E-05	1.9523911E 03	1.2122247E-02	7.3376900E 01
1.4800000E 04	8.0967217E 03	6.5653061E 01	8.9999987E 01	9.9226478E-01	-0.0000000E-39	0.0000000E-39
2.2377935E 04	-5.2901273E-01	-5.7906848E-01	0.0000000E-39	6.1517478E-01	6.1517477E-01	8.1647683E-09
1.6690728E 04	1.0000072E 00	9.0000000E 01	1.8152357E-05	2.1924089E 03	3.7678461E-02	7.4593117E 01
1.5000000E 04	7.9144752E 03	6.4257302E 01	8.9999987E 01	9.9221747E-01	-0.0000000E-39	0.0000000E-39
2.2836896E 04	-4.9463328E-01	-5.0412133E-01	0.0000000E-39	4.9880040E-01	4.9880040E-01	5.1992248E-08
1.6957685E 04	1.0000276E 00	9.0000000E 01	3.5783823E-05	2.5518166E 03	1.3348818E-01	7.6122987E 01
1.5200000E 04	7.6846954E 03	6.2573347E 01	8.9999987E 01	9.9167076E-01	-0.0000000E-39	0.0000000E-39
2.3650797E 04	-3.5242223E-01	-3.3286553E-01	0.0000000E-39	2.3500089E-01	2.3500088E-01	9.9749666E-07
1.7282301E 04	1.0000440E 00	9.0000000E 01	2.0531902E-04	3.2421275E 03	6.5800690E-01	7.8835991E 01
MAIN EMUS = -0.29802E-06						
1.5252622E 04	7.5721128E 03	6.1770828E 01	8.9999987E 01	9.8845857E-01	0.0000000E-39	0.0000000E-39
2.4815457E 04	-4.0342019E-04	5.1147716E-04	-0.0000000E-39	-2.9802322E-07	4.2435672E-07	2.1138030E 00
1.7437529E 04	1.1212211E 01	-8.9999986E 01	-2.6547938E 05	3.7785821E 03	1.4378852E 00	8.2718190E 01

STR AT 01517 XR1= 00000 XR2= 75030 XR4= 31776 XR3= 46160 XR5= 00000 XR6= 00000 XR7= 00000

APPENDIX C

CHECKLIST OF ELEMENTS IN COMMON AND SUBROUTINE IN WHICH USED

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
/DATA/	X	X	X	X	X	X	X	X	
RMAX	X	X							
RMIN	X	X							
TMAX	X	X							
TMIN	X	X							
PMAX	X	X							
PMIN	X	X							
PRNT	X	X							
RELERR	Presently not used								
AØ		X							
BØ		X							
RØ		X	X			X			
THETAØ		X	X			X			
PHIØ		X	X			X			
PLUS	X	X						X	
NPØWER	X	X	X			X			

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
NPLØT		X	X						
J	X	X							
NUAR	X	X							
N1	X								
EN	X	X	X			X	X		
DNDR	X						X		
DNDT	X						X		
DNDP	X						X		
EMU	X	X	X		X				
RTYSQR	X			X	X				
F	X	X	X					X	
F2	X	X	X			X			
C1	X	X				X			
FH	X	X		X		X		X	
CØSPSI	X	X		X		X		X	
STNPSI	X	X		X		X		X	
DFHDR	X			X		X			
DCPDT	X			X		X			
DCPDY1	X			X		X			

	MAIN	OUTPUT	FOR	PDWELL	CDPAL	4
DCPDY2	X		X	X		
DCPDY3	X		X	X		
SP2	X		X			
EMUINT	X	X	X			
EMUS	X	X	X	X		
N	X		X			
GNU	X		X			
MUFLAG	X			X		
NTEST	Presently not used					
/HBANK1/	X	X	X	X	X	X	X	X
MØRDER	Presently not used					
NØHALF	Presently not used					
NØDØUB	Presently not used					
HBANK	X	X				
NØEQ	Presently not used					
FINVP	Presently not used					
FINVPI	Presently not used					
YØ	X	X	X	X	X	X	X	X
YD	X		X		X			

	MAIN	OUTPUT	OUTPUT	FIELD	FIELD	POWER	DEPOLE	PALOC4
MA	Presently not used							
/CSCR/	X	X	X	X		X		X
C	X	X		X		X		
RCT	X		X			X		
S	X	X		X		X		
RST	X					X		
Z	X							X
EM	X	X				X		
TERM	X	X				X		
TERM2	X	X				X		
RMØD			X					X
RARG			X					X
YØ6	Presently not used							
/CONST/	X	X						
ØRDER	X	X						
EUBAR	X	X						
ELBAR	X	X						
YCLØW	X	X						
HMAXT	X	X						

	MAIN	OUTPUT	OUTPUT	FILE	POWER	DPALC	4
HMINT	X	X					
KD	X	X					
/NEW/	X	X					
PLØTØ	X	X					
RDØT	X	X					
/EPSTN/	X		X				
EPSTIN	X		X				
PRØPT	X		X				
/GAUSS/	X		X	X		X	
YSQUAR	X			X			
DCPDR	X			X		X	
DCPDP	X			X		X	
DFHDP	X			X		X	
F1T				X			
DNMNTR				X			
DEL2S			X			X	
/PØWLØS/	X		X			X	
CØSA	X					X	

	MAININPUT	OUTPUT	FILE	FIELD	POWER	DEPENDENT	CALCOMP
Y	X				X		
DMDR	X				X		
DMDT	X				X		
DMDP	X				X		
DMDY1	X				X		
DMDY2	X				X		
DMDY3	X				X		
DMDSI	X				X		
DMDDSI	X				X		
DMUDR	X		X		X		
DMUDT	X		X		X		
DMUDP	X		X		X		
DMUDY1	X				X		
DMUDY2	X				X		
DMUDY3	X				X		
DMUDSI	X				X		
EMD	X				X		
EMRAD	X				X		
/EXFLD/				X	X		

	MAIN	OUTPUT	OUTPUT	FIELD	POWER	POWER	DEPOSAL	CALCO4
D2CY1R				X		X		
D2SY1R				X		X		
D2CY2T				X		X		
D2SY2T				X		X		
D2CY3P				X		X		
D2SY3P				X		X		
/GRAPHO/	X	X						X
XMAXO	X	X						X
XMINO	X	X						X
YMAXO	X	X						X
YMINO	X	X						X
DATE	X	X						X
/GRAPH1/	X	X						X
XMAX1	X	X						X
XMIN1	X	X						X
YMAX1	X	X						X
YMIN1	X	X						X
PLT	X	X						X
/RECT/	X		X				X	

	MAIN	OUTPUT	OUTPUT	FIELD	OPCODE	PODERSL	PCALOC4
DD	X		X				X
SØA	X		X				X
LB	X		X				X
/RDØTS/	X		X				
JUMP	X		X				
NYD1	X		X				
/BLK1/		X					X
STZM5		X					X
HPRIME		X					X
PKDELN		X					X
AMBDL		X					X
NO		X					X